Vol. LXXII OCTOBER, 1920 No. 4

ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

Edited by

LEWIS STEPHEN PILCHER, M.D., LL.D.
of New York

With the Collaboration of

SIR WILLIAM MACEWEN, M.D., LL.D. of Glasgow
SIR W. WATSON CHEYNE, C.B., F.R.S. of London

J. B. LIPPINCOTT COMPANY, PUBLISHERS
MONTREAL PHILADELPHIA LONDON

Entered at the Post-Office at Philadelphia and admitted for transmission through the mails at second-class rates.
Price, $7.50 a year.

NOVOCAIN

(PROCAINE-METZ)

And Other Local Anesthetics Admitted to the Mails

By a recent ruling of the Postmaster General, local anesthetics may be sent through the mails, provided: "The container of the article mailed is plainly labeled to show its contents, is marked 'Poison', and bears the label and superscription of the manufacturer thereof."

We are prepared to furnish Novocain-Suprarenin (N-S) Tablets "A", "B", "C", "E", "H" and "T", and Novocain Tablets "D" and "F", representing various strengths for various usages, in all conditions in which local anesthesia is indicated, as well as Novocain in powder form.

H. A. METZ LABORATORIES, Inc.
122 Hudson Street
New York

ANNALS *of* SURGERY

VOL. LXXII OCTOBER, 1920 No. 4.

THE INDICATIONS FOR ACTIVE IMMEDIATE MOBILIZATION IN THE TREATMENT OF JOINT INJURIES *

BY CH. WILLEMS, M.D.
OF LIÉGE, BELGIUM
COLONEL IN THE ARMY OF BELGIUM; PROFESSOR OF CLINICAL SURGERY IN THE UNIVERSITY OF LIÉGE

I DO not consider it necessary to review in detail the technic and results of this method, all of which I have already published in full in the Transactions of the Interallied Conference on War Surgery, in the *Bulletin of the Societé de Chirurgie de Paris,* the *Bulletin of the Académie de Médecine de Paris,* the *Archives Medicales Belges,* the *Bulletin of the Académie de Médecine de Belgique, and in Surgery, Gynæcology and Obstetrics,* the *Medical Record,* etc.

But I learn by a perusal of the published observations of other surgeons, that the method is almost never correctly applied. They content themselves with partial results, because these greatly excel anything obtained by the old classical methods of treatment. But this is not sufficient. In purulent arthritis, for example, it does not suffice to conserve mobility; it is necessary to prevent entirely, or almost entirely, the muscular atrophy. If muscular atrophy is present as a result, it means that the movements have been commenced too late, have been too infrequent or have not been continued long enough.

Frequently the authors indicate that these patients with purulent arthritis have begun active movements, but have been obliged to discontinue them, not having the power to execute them at a given moment. In these cases one ordinarily finds evidences of pus retention, the result of insufficient mobilization. To remedy this it is necessary, instead of stopping the movements, either to enlarge the incisions, which are often too small, or to make the movements more complete. It should be emphasized that a minimum amount of pocketing of pus suffices to arrest voluntary movements.

Further, the patient always attempts at the beginning to escape the obligation of movement, which he regards as a disagreeable task. I am not able to insist sufficiently on the capital importance of having at one's disposal a personal nursing attendant, devoted to duty, and thoroughly familiar with the method, as it is on the nursing of the wounded man that the success in great part depends.

* Read by title before the American Surgical Association, May 3, 1920.

What are the indications as to active mobilization in the wounds of joints *complicated by fracture?* In my early publications I have said that the method was not applicable to extensively comminuted fracture of joints when the lines of fracture extended to the diaphysis. Since then the facts have made me admit that we may employ it in all fractures of joints, whatever the extent of the lesions, although, it must be understood, in a modified form. In the elbow, for example, the major fractures admit perfectly of treatment by active limited movements. It is true the movements do not maintain the fragments in perfect reduction, but the fragments are disengaged, pushed back from the interarticular space, and a sufficient regularity of the articular surfaces preserved to insure a certain range of mobility, much better than one could secure by immobilization. In certain cases the result can be improved later by the removal of an osseous spur which constitutes a mechanical obstacle.

Surgical fixation of the fragments which reëstablishes at once the physiological conditions may render great service in these cases, but not when the lesion involves the cartilage, because in war wounds osteosynthesis is often followed by hyperostosis.

If the articular wound is complicated by infection in addition to fracture, mobilization is still more strongly indicated, as it alone can give drainage, which is not perfect by reason of necessary limitation of the movements, but in all cases superior to that accompanying immobilization. Osteosynthesis in the midst of infection may facilitate the movements, but the plates will have to be removed secondarily.

With a fractured knee it is evident that it is not a question of having the patient walk immediately, but mobilization in bed is possible, especially if one adds thereto a continuous extension which furnishes a certain fixation to the fragments, as well as a point of application for muscular action. This mixed method of treatment of articular wounds complicated by major fractures, by extension combined with active movements, gives functional results far superior to those obtained by other methods.

Let us examine now as to whether intra-articular fractures with destruction and removal of a large fragment of the epiphysis admit of treatment by mobilization. I am speaking now of cases where one-third or more of a condyle has been lost. In these cases the danger lies in a lateral bowing of the joint. This danger is especially present at the knee, where lesions of this nature have been considered heretofore as calling for immediate resection. I believe that this is an error. In the elbow in cases treated conservatively after this manner, with active mobilization, I have seen sufficient strength to render good service. I have seen the knee readapt itself rapidly, permitting the patient to walk and use the joint with flexion and without pain. Sometimes it is necessary to protect the limb with a jointed brace, but at

the same time the condition in walking is far superior to that accompanying an ankylosis. If unfortunately the result should turn out unsatisfactorily, there is always the opportunity to practice secondary orthopædic resection.

I emphasize then that bony lesions constitute no contraindication to active mobilization, and that in such cases they give unhoped-for success.

I am now at the last class of injuries, comprising extensive destruction of the tissues uniting the joints, especially the ligaments, and particularly the anterior and crucial ligaments of the knee-joints. Whether their destruction is primary or consecutive to joint suppuration does not seem to me to interdict all movement. In cases of this type observed recently, whether accompanied by section of the patellar ligament or by destruction of the crucial ligaments, which have been treated with continuous extension combined with active movements, I have seen a correction of the posterior subluxation of the tibia, and have obtained a cure with partial conservation of movement, even in the presence of a simultaneous purulent arthritis. It must be understood that such treatment demands unremitting attention and perseverance on the part of surgeon and nurses.

In a résumé of the actual state of the question, I estimate that active mobilization knows no contraindications by reason of extent of bony lesions, or extent of destruction of the ligaments. I would urge surgeons not to abandon the method at the first difficulty, but, on the contrary, to pursue it to the end, with the conviction that the functional result will be the more brilliant in the same proportion as the efforts to obtain it have been more energetic and tenacious.

ON FRACTURES OF THE FOREARM IN THE REGION OF THE WRIST

WITH SPECIAL REFERENCE TO THE DIFFERENT TYPES OF RADIUS FRACTURE, THEIR MANNER OF ORIGIN AND MECHANISM *

By Abraham Troell, M.D.
of Stockholm, Sweden

In some papers published within the last few years I have devoted my attention to the question of the treatment of the typical radius fracture—*fractura radii classico loco.* I have therein spoken of my own experiences in consecutive cases during the year 1911, amounting in all to rather more than 200. The essential value of this material was the uniformity with which it was followed, and also the completeness with which it was röntgenologically examined (by Professor G. Forssell and his assistants). That I am now returning to these cases is due chiefly to the fact that they offer no few details of röntgenanatomical interest. For, from an anatomical point of view, they represent, taken altogether, a fairly complete variety of the different types of fractures. And, from a clinical point of view, the röntgenological facts are calculated, if arranged together with certain anamnestic and other data in the records (the kind of trauma, patient's age, stage of development of the respective part of the skeleton, etc.), to facilitate to some degree the understanding of the genesis and mechanism of origin of the radius fracture.

With regard to the question of the different anatomical types of the radius fracture—it is not difficult to prove that our knowledge of the subject has hitherto been unsatisfactory. Up to now the literature obtainable has been lacking among other things in uniform and rational principles of classification for radius fracture, and this, not only when comparing the works of different, yea, even responsible and very experienced authorities, with each other, but also when taking separate cognizance of the statements of individual authors. I will give two examples, both of recent year's date.

Kaufmann divides (the year 1912) radius fractures into the following groups:

I. Radius fracture without dislocation of the place of fracture.
II. Radius fracture with dislocation of the place of fracture.
    1. Transverse and oblique fractures.
        a. Automobilist fractures.
        b. The volar displacement of the peripheral fragments (so-called Smith-Linhartscher type).
    2. Comminute fractures.

* From the Surgical and Röntgenological departments of the Serafimer Hospital in Stockholm (Sweden).

3. The fracture of the ulnar styloid process.
4. The fracture of the ulnar margin of the radius.

Pilcher, on the contrary, treats (year 1917) the same chapter by dividing it up under the following headings:

a. Perpendicular wedge-like impact of the carpus against the articular cup of the base of the radius.

b. Splitting of the lower fragment by descent into it of the lower end of the upper fragment.

Explosive splitting of lower fragment of radius.

Backward displacement of lower fragment of radius.

Outward displacement of lower fragment.

Anterior displacement of the lower fragment.

Epiphysial separations.

Dorsal untorn periosteum.

Incomplete fractures.

Fracture of the ulnar styloid process.

Associated fracture of the carpal bones.

Associated injuries to the periarticular structures and diastasis of the ulna.

As to the manner of origin and mechanism of radius fracture—it is on the one hand natural that the conception thereof must be built on a due regard not only to the nature of the trauma, but also to the stage of development and solidity of the part of the extremity in question. But, on the other hand, it is remarkable that such regard in the literature on the subject is hitherto either not taken at all, or at most but in incomplete fashion.

The mechanism of the typical radius fracture has been interpreted in various ways. Already at an early period it was established that the fracture arises through a fall on the prone and extended hand, or through other violence having the same effect MacLeod [1] speaks of a case which illustrates the origin of such a fracture with almost the lucidity of an experiment. It concerned a young man who had injured himself whilst boxing with an older and stronger man. The fingers of both of them were entwined in each other's, and the palm of each was pressed hard against the other one's in prone direction. The hand of the younger man was strained to the uttermost and was forced at last to give way, this resulting in violent pains and a typical radius fracture with the usual bayonet deformity. Pilcher relates in connection with the above some characteristic cases of his own. In one of these a woman who was standing on a chair in front of a table slipped, and in falling managed with the fingers only of her one outstretched hand to catch hold of the latter. Her hand was thereby bent violently backwards and a typical radius fracture ensued. Another patient injured himself through letting the weight of a packing-case, which he together with an assistant was to carry down a flight of stairs and which he was nearly about to drop, rest for an instant on his dorsally deflected hand alone. Amongst my own printed matter there occur—which may already be mentioned in this connection—various cases where the details at the moment of fractures are fairly lucidly described. For instance, patient 148 who received a hard blow in the hollow of his hand from a pick-axe, so that the forearm was bent forcibly in dorsal direction (Group II*a*). Or amongst other cases 81 (see under I*d*), cases 54 and 72 (see under II*c*), case 27 (see under II*d*) and the cases 110, 113 (see II*a*), case 99 (see II*b*), case 76 (see II*c*), and case 164 (see II*d*), the last five being chauffeur fractures.

The theoretical explanation of how the violence thus described may be thought to lead to fracture has, during different periods, given entirely different results.

At first it was more often than not concluded that the radius fracture was a *compression-fracture, i.e.,* was caused by the violent pressure of two forces operating in opposite directions to each other (coup et contrecoup). [Dupuytren,[1] Goyrand,[2] Nélaton,[3] and Middeldorph,[4] etc.] The post-mortem experiment by which Nélaton tried to illustrate this theory is well known. The forearm exarticulated in the elbow-joint was placed vertically with the hand extended maximally and resting on a firm support. After sawing off the olecranon a strong blow with a hammer was given on the upper end of the bone of the forearm and the result obtained was, as a rule, radius fracture in the typical area. The clinical analogy to the procedure was thought to be thus, that the forearm when the outstretched hollow of the hand through a fall forwards touched the ground, formed a right angle to the hand, and that the proximal carpal bones ranged themselves as a valve against the support; the weight of the falling body pressed the radius against this valve, with the consequence that either the latter or the radius gave way and broke; if the valve was the stronger, radius fracture set in.

The most usual contrary theory interprets the radius fracture in quite another way as *wrench* (tearing) *fracture.* Already suggested by Bouchet[5] and others, it was completely formulated by Lecomte. Besides the clinical explanation, the latter based his opinions concerning same on the negative result of Nélaton's post-mortem experiment if made after intersection of the ligamentum radiocarpeum volare. [If, however, the radius by this latter experiment is always fixed in the manner described by Brossard, *i.e.,* so that the lower radius epiphysis is not luxated in dorsal direction during the execution of the experiment, then radius fracture ensues (Destot and Gallois).] This opinion has since been accepted in the main by the generality of authors, eventually with certain modifications, such, for instance, as Löbkers, who interprets many of these fractures as pure wrench (tearing) fractures, and with regard to certain of them is of the opinion that "they are caused solely from coup et contrecoup; the typical oblique fracture on the base of the bone ensues through a combined action of both forces mentioned together."

Lastly, Hennequin's theory (resembling that of Nélaton) may be called to mind in this connection, and, on the other hand, those theories which might be called essentially terminological variations to be found in many authors on this subject. I allude here amongst others first, to Helferich's treatise wherein the typical radius fracture is designated as a simultaneous wrenching and snapping (Abknickungs) fracture, caused by drawing on the tightly knit volar radiocarpal ligament, and at the same time violent impact of the proximal carpus against the dorsal margin of the base of the radius. Secondly, I refer to Kuhn's argument, which being interpreted, means that the radius fracture is not a wrench fracture, but a "*Quetschbruch.*" Without going into further details here, I will but express my doubts as to increased perspicuity on the question of the mechanism of radius fracture being gained in this way. The best prospects therefor are obtained by keeping, as far as possible, to the limited, generally prevailing conception of that part of the science of fractures in question—wrench, compression, flexion and torsion fractures—avoiding terms the eventual relation of which to those mentioned is more or less obscure.

A short statement of the purpose of each of the four terms given is to be found amongst others in the author's work on leg fracture. The fact is, however, not therein mentioned that the principal differences between flexion and compression fractures do not need under every circumstance to be so great, that, in other words, in many injuries it is a question of a combination of flexion fracture and (longitudinal) compression fracture. As the drawing to the right in Fig. A shows, a flexion fracture can arise among other things through a strong compression from end to end of a tubular bone with the shape of a crooked staff. The fracturing begins superficially in the cortex on the vertex of the convexity of the bone, whereas the fracture line

afterwards often appears broadest and takes a more or less transverse course. The fracture arises through a disjointing ("Zugspannung") of the different bone particles on the convexity in a longitudinal direction of the bone and towards each of the both ends of the bone, whilst a simultaneous compression ("Druckspannung") coming from the ends of the bone takes place on the bone particles situated on the concavity. In the same degree as the bone in question exposed to violence has from the beginning more the form of a straight than a crooked staff, so is the disjointing component moved from the convex side to the concave, and the compresing component from the concave to the convex. Both components become completely inverted in the event of a flexion fracture arising in the manner shown in the sketch to the left in Fig. A, and this, whether it be a question of a straight or crooked bone. The compression fracture—the character of which is more complicated than flexion fracture—likewise arises under influence of two equally strong forces acting against each other. If the violence concerns a bone which consists mainly of spongiose tissue, *e.g.*, the distal radius epiphysis, then this individual spongiose lamella will be curved, outward bent and eventually fractured, with an intermediary beginning and at first-hand—if it is a question of longitudinal compression—the fracture line longitudinally extended (Fig. B). Has the bone—in this case radius diaphysis—a strong compact, *i.e.*, if it reacts against the trauma in the same manner as a hollow cylinder, then the longitudinal compression ("Stauchung"—Zuppinger), if it continues after the longitudinal fissure has set in, may lead to further fracturing. The latter begins then apparently on the vertex of the already curved convexity of the bone lamellæ (at a and b in Fig. B), thus at the ends of the longitudinal fissure, and continues transversely out towards the surface of the diaphysis, so that a more or less comminute fragment is broken off (according to what is schematically shown in the drawing to the right in Fig. B).

The fractures of flexion, which form the chief part of all fractures, occur in reality most often during simultaneous longitudinal compression, and that more so "because the muscular system extending over the bones violently contracts at the moment of danger" (Zuppinger); that such is the case is shown by the argument just quoted from Zuppinger regarding the effect of the disjointing of the single bone particles on the one side of the bone and the compression on the other. Concerning the nature of the anatomical effect of the violence, even the following circumstance may have some influence—as far as I can understand, in many cases and more especially in the bone of a young person—namely, that the periosteum on account of its considerable relative strength can prevent the fracturing on the vertex of the bone convexity which constitutes the first beginning of the fracture of flexion (see drawing to the right in Fig. A); and thus the continuation of the influence of the trauma is established predominating according to the theories of compression fracture. Finally, with reference to the bone of the young, it must be remembered that it is more elastic, less brittle and therefore offers more resistance to a longitudinal compression than is the case with that of an adult. Thus, before or instead of a longitudinally acting trauma on the bone leading to a longitudinal fracturing, there may be in the case of the young, only that change in the form take place which—according to Zuppinger—"we are accustomed to see as a consequence of stooking (stauchung) in plastic bodies; a circular torus formation which with some amount of reason may be called torus-fracture." (Quervain's and Iselin's stauchung fracture on the epiphysis of the young, the Frenchman's fracture par tassement).

To what has been said here concerning flexion and compression fracture statics may finally, for the sake of completion, be given a definition of wrench-fracture. It is brought about under the influence of two equally strong parallel forces acting in opposite directions to each other. It begins where this disjointing influence first exceeds the elastic power of the bone and passes in the simplest imaginable, fully typical cases rectangularly towards the direction of the pulling (wrenching). It is false to talk about pure wrench fractures in those cases where it is a question of two disjointing

but not parallel forces, *i.e.*, in patella fracture or—above all—typical radius fracture (Zuppinger).

I will now return after this deviation to my own material. In the enclosed table I have arranged a concentrated grouping thereof. How the injury in individual cases develops is more completely shown by the following statement (from want of space the records are not given in detail).

I. FOREARM FRACTURES IN THE REGION OF THE WRIST IN INDIVIDUALS WITH INCOMPLETE OSSIFICATION (54 CASES)

A. Transverse Fracture of Radius and Ulna (Figs. 1 and 2, Case 129).—The group embraces 13 cases, the ages of the patients varying from four to thirteen years, with an average age of eight years.[1] In 10 of them both the radius and ulna were with certainty injured (Cases 4, 69, 107, 129, 137, 150, 153, 155, 163, 197), in three was ulna presumably, but according to X-ray plate not with certainty, injured (Cases 109, 169, 199; in the last-mentioned case there was in all probability epiphysial separation in the ulna). The fracture line was transversal (Case 153), somewhat oblique, and lay 2–5 cm. above the radiocarpal joint.[2]

Cases 163, 169 and 199 (respectively, twelve, thirteen, and seven years) have somewhat the appearance of a typical radius fracture with the distal fracture fragment pressed in dorsal and proximal direction and impacted in the diaphysis.

The trauma causing the same was in the case of all the patients a fall (down stairs, from a swing, or such like). One patient (Case 197) had, whilst bob-sleighing, struck his right hand against a tree with such force that the arm thereby came into a rectangular position at the site of fracture. Patient 129 was stated to have been injured by the fall through direct violence to the arm.

B. Torus Fracture of the Radius, Eventually with Simultaneous Ulna Lesion (Figs. 3 and 4, Case 100; Fig. 5, Case 167; Figs. 6 and 7, Case 178).—The group embraces 12 cases with the age of the patients from four to fourteen years and an average age of ten years. In 6 of the patients both bones of the forearm were injured (Cases 20, 57, 100, 167, 186, 194), in 6 only fracture of the radius could be radiologically diagnosed (Cases 19, 101, 147, 178, 181, 187). The radius fracture lay 2½–4¾ cm. above the radiocarpal joint.

The radius lesion appeared—apart from Case 167, where the frontal plate showed a limited transversal thinning in the lateral two-thirds of the bone and which therefore should be placed in group C—as a torus (folding) in the cortex which on the X-ray plate was seen to lie only radially in Case 20; only dorsally in Cases 100 and 101; both radially and dorsally in Cases 147, 167, 181, and 194; in radial, dorsal and ulnar direction in Cases 19 and 57; in radial, volar, and ulnar direction in Cases 178, 186, and 187.

The ulnar lesion was observed as a transverse fissure in Cases 20 and

194; oblique fissure in Cases 57 and 167; epiphysial separation (presumably) in Cases 186 and 187; fracture of the apex itself in Case 100.

The trauma had been caused by a fall in the case of all the patients except one (Case 20, nine years of age), where a play-fellow had wrung him violently by the hand; patient 178 (thirteen years of age) had fallen over whilst cycling, and according to his own statement had, in falling, tried to stop himself with his hand in volar direction. The site of cortex folding (tassement)—also in volar direction—is with regard to anamnestics of interest in this case as in that of patients 186 and 187 (fourteen years of age, right and left arm injured in same individual). The latter had, seven days previous to first visit to hospital, fallen over whilst cycling and driven both hands into the ground. On the day of the visit he had slipped in the street and in falling had his hands extended dorsally.

C. Transverse or Oblique Fracture with Simultaneous Visible Cortex Torus (Figs. 8 and 9, Case 111; Figs. 10 and 11, Case 131; Fig. 12, Case 111*a*; Figs. 13 and 14, Case 131*a*).—The group embraces 9 patients of an age of from four to eighteen years (average age eleven years). In all of these—possibly with exception of Case 191—were both bones of the forearm injured, the fracture lay 1½–5¼ cm. above the wrist.

Röntgenanatomically the injury was of following character:

Case 23.—Transverse fracture of both bones with suggestion of dorsal cortex torus (folding) on the radius and ulnar (medial) on the ulna.

Case 132.—Transverse fracture of both bones with the ulna fissure broadest on the ulnar and volar side, and radial (lateral) and dorsal cortex torus (folding) of the radius.

Case 111.—Transverse fracture of the radius (which was curved with the concavity in dorsal direction) which began on the volar side (where fissure was broadest) and radially; cortical folding on the dorsal and ulnar side of the ulna which was curved with the concavity on the dorsal side.

Case 111*a*.—Oblique fracture of the radius with the dorsal concavity and with the fissure broadest on the ulnar side; slight radial and dorsal cortex torus (folding) of the ulna which was curved with radial and dorsal concavity.

Case 191.—Oblique fracture of the radius with the fissure broadest on the ulnar and volar side and folding on the radial side; presumably epiphysial separation of the ulna.

Case 106.—Transverse fracture of the ulna, beginning on the ulnar side (?) and cortex torus (folding) on the radius radially (?) and dorsally.

Case 154.—Oblique fracture of ulna with cortex torus (folding) radially; transverse fracture of radius with cortex torus (folding) dorsally and radially.

Case 131.—Transverse fissure in the radius (broadest on the ulnar side) with cortex torus dorsally and radially; fracture of the apex of the ulnar styloid process.

Case 131*a*.—Transverse fissure in the radius with cortical bone torus (creasing, folding) radially, dorsally, and ulnarally; epiphysial separation—atypical, with small oblique diaphysis crack radially—in the ulna, the fracture line presumably broadest on the ulnar side.

The trauma had been caused in the case of all these patients by a fall (from hammock, tram, and so on), whereby the patient had tried to help himself with his hands.

D. Epiphysial Separation (Fig. 15, Case 83; Figs. 16 and 17, Case 156; Figs. 18 and 19, Case 128).—Hereto belong 16 patients of an age from nine to eighteen years (average age fourteen years). In 3 cases only (Cases 25, 128, and 156) was it evident that the ulna was also injured; in the remaining 13 only radius lesion was observable (Cases 63, 81, 83, 88, 95, 119, 120, 142, 143, 146, 162, 166, and 174). In the one (Case 128) of the three first-named patients it was a question of an epiphysial separation even in the ulna, in another (Case 156) no change in the ulna could be discovered on the first plate but a couple of weeks later a distinct callus was found.

In Cases 83, 88, and 120 there was nothing at all abnormal to be discovered on the front-view photograph, whilst the lateral-view photograph showed dorsal displacement on the fracture area. It was identically the same in the case of patient 95, apart from the fact that there, even as in Cases 146 and 162, there occurred an unevenness of the cortex in the vicinity of the epiphysial line. Case 166 showed after replacement nothing röntgenologically abnormal. Case 128 offered, besides the already mentioned character of the ulna lesion, interest with regard to the appearance of the radius injury: close to the epiphysial line a little triangular fragment had been dorsally torn off; similar discoveries were made in Cases 146 and 156.

The trauma causing the fracture was a fall (forwards, backwards, etc.) in all the patients except one (Case 81). The latter's injury was brought about by his hand fastening between a banister and the wall.

E. Typical Radius Fracture (Fig. 20, Case 114; Fig. 21, Case 170; Figs. 22 and 23, Cases 151 and 152).—The group embraces four patients of an age from sixteen to eighteen years (average seventeen and one-half years). In the case of patient 114 the ulnar styloid process was also fractured, in the others only radius. The fracture of the radius lay 2¼–3½ cm. above the wrist.

In Cases 114 and 170 the fracture had quite an ordinary appearance. The latter offered a special interest inasmuch as the epiphysial line there appeared broad and distinct (and yet the break in the bone had not occurred there, but in close proximity). In patients 151 and 152—the left respectively right hand of the same individual—there occurred together with the transverse fracture an intra-articular splitting of the distal fracture fragment.

The trauma was caused by a fall in patients 114, 151, and 152. With

regard to patient 170, it was a case of direct violence (suggesting the same manner of origin as in fracture of flexion): the patient had had the dorsum of his forearm trampled on by a horse.

II. FOREARM FRACTURES IN THE REGION OF THE WRIST IN INDIVIDUALS WITH COMPLETE OSSIFICATION (152 CASES[3])

A. Typical Radius Fracture (Figs. 24 and 15, Case 204; Figs. 26 and 27, Case 130; Fig. 28, Case 134; Fig. 29, Case 71; Fig. 30, Case 24; Fig. 31, Case 67; Fig. 32, Case 168; Fig. 33, Case 207; Fig. 34, Case 211; Fig. 35, Case 115; Fig. 36, Case 90; Fig. 37, Case 209; Figs. 38 and 39, Case 52; Figs. 40 and 41, Case 42; Fig. 42, Case 7; Figs. 43 and 44, Case 53; Figs. 45 and 46, Case 113; Fig. 47, Case 10; Figs. 48 and 49, Case 104).—In this group are included 104 patients of an age from twenty-one to seventy-five years of age (average age forty-eight and four-fifths years).

In 64 cases (61.5 per cent.) the ulna was injured as well as the radius; most often in such wise that the ulnar styloid process was fractured, but three times (Cases 10, 104, and 200, Figs. 47 and 49) so that a transverse or oblique fracture was present at the base of the capitulum ulnæ at the same height as the radius fracture, and about 1 cm. above the styloid process. In 4 of the cases with the ulnar styloid process broken off (Cases 74, 77, 78, and 84) this lesion could not be röntgenologically diagnosed until a photograph was taken later on, when a distinct callus or such like betrayed its whereabouts. In 3 of the patients with ulnar styloid process fracture (Cases 58, 70, and 78) there also occurred, judging by röntgen pictures, an abnormally wide diastasis in distal radio-ulnar connection; a positive one of the same kind was, moreover, observed in 4 cases (Cases 61, 62, 68, and 93), a probable one in 2 cases (Cases 90 and 204, in which two the ulnar styloid process was off) (see Figs. 24 and 36).

The radius fracture lay 1½–3½ cm. above the radiocarpal joint in all cases, except one where this distance amounted to 6½ cm. (Case 113, Figs. 45 and 46); in 80 cases, the whole group included in the calculation, the position was 2–2½ cm. above the joint.

Röntgenanatomically the injury appeared when in its simplest and most typical form as a transverse fracture of the radius without dislocation and situated 2 cm. above radiocarpal joint (Case 204, Fig. 24); sometimes with a splitting or smashing of the bone (Cases 130 and 134, Figs. 26 to 28), in some cases even so that small cracks radially (Cases 71 and 24, Figs. 29 and 30) or ulnarally (Case 67, Fig. 31—a triangular fragment broken off) were to be seen. The lateral view shows distinctly the course of the fracture line and the absence (Case 204, Fig. 25—the periosteum appears to be untorn) or the more or less expressed presence of dorsal dislocation (Cases 168, 207, and 211, Figs. 32 to 34), eventually, also, the occurrence of a splitting of the radial dorsal labrum (Case 115, Fig. 35). In other cases (Cases 90, 52, and 209, Figs. 36 to 39) the course of the fracture line is fairly straight, but the distal fracture fragment, without

pronounced wedging, markedly displaced in radial and dorsal direction; or there is a considerable typical dislocation together with impaction (Case 42, Figs. 40 and 41), or the fracture line appears in the front-view photograph something like the form of an inverted S, but without dislocation (Cases 7 and 53, Figs. 42 and 43). Already mentioned is Case 113 (Figs. 45 and 46), which concerns a transverse fracture lying considerably higher up on the radius, as well as those cases (Cases 10, 104, and 200, Figs. 47 to 49) where not only the ulnar styloid process is broken off, but where there is a question of a transverse or oblique fracture immediately above capitulum ulnæ. Furthermore, it is interesting to note, firstly, Cases 134 and 113 (Figs. 28 and 46) which show a fold in the cortex reminding one of a cortical torus in the young—which view may possibly have originated partly through reposition measures—secondly, some cases in which a greater breadth of the fissure on the volar side (Cases 11, 207, and 211, Figs. 33 and 34) and on the radial side (Case 113, Fig. 45) is quite obvious.

In all cases but Case 14 the injury has been caused by a fall (from ladder, on smooth ice, backwards, etc.). The patient (Case 171) got a fracture whilst escaping from an encounter with the police; patients 110 and 113—chauffeurs—got a blow when cranking an automobile from the rebound of the winch; Case 148 through bending (see page 434).

Besides the 19 cases reproduced, the following 85 patients have been reckoned to this group: Thirty-two cases of about same appearance as Case 204, namely, 3, 8, 12, 18, 22, 36, 38, 45, 49, 56, 61, 64, 66, 75, 78, 98, 110, 112, 118, 121, 122, 125, 133, 148, 149, 161, 171 to 173, 180, 182, and 184. Four cases with appearance as Case 130 (Cases 124, 139, 140, and 158), and Case 11, most resembling Cases 130 and 42. One case like 134 (192). Six cases like Case 71 (Cases 70, 82, 84, and 93, somewhat impacted in the lateral-view photograph, 188, and 198). One case like Case 24 (51). Two cases like Case 67 (68 and 115 [some splitting]). One case like Case 90 (89). One case like Case 52 (108). Eighteen cases like Case 42 (5, 21, 32, 33, 50, 58, 59, 62, 65, 79, 80, 92, 117, 165, 179, 190, 203, and 208) and Case 13, most closely resembling Cases 42 and 10. Two cases like Case 7 (2 and 136). Nine cases like Case 10 (1, 9, 44, 47, 48, 74, 126, 183, and 196) and Cases 30, 37, 73, and 138, most closely resembling Cases 10 and 204. Two cases like Case 104 (105 and 200).

B. Radius Fracture with Longitudinal Fissures, too, Extending into the Radiocarpal Joint (Fig. 50, Case 159; Fig. 51, Case 29; Fig. 52, Case 210; Fig. 53, Case 15; Fig. 54, Case 99; Fig. 55, Case 97; Figs. 56 and 57, Case 40; Fig. 58, Case 157; Figs. 59 and 60, Case 17; Figs. 61 and 62, Case 17*a*; Fig. 63, Case 55; Figs. 64 and 65, Case 118*a*).—The group comprises 28[4] patients of an age from twenty-four to sixty-nine years of age (average age forty-eight and two-fifth years). In 18 of them (64.3 per cent.) the ulnar styloid process was most certainly injured (this even as in the foregoing group was occasionally only to be verified by an X-ray photograph taken a week or two after the injury). In 4 of the patients with

ulnar styloid process fractures (Cases 31, 77, 159, and 210) the X-ray photograph showed a distal radio-ulnar diastasis, which was also observed in some cases with uninjured ulna (Cases 91, 99, 123, and 202) (see Figs. 50 and 54). The position of the radius fracture was 1½–6½ cm. above the radiocarpal joint, one case respectively of 1½, 4¼, 5, and 6½ cm., and 24 cases of from 1¾–3¼ cm.

The picture varied röntgenanatomically, inasmuch as the intra-articular longitudinal fracturing sometimes assumed an ulnar position (Cases 159, 29, 210, 15, and 99, Figs. 50 to 54) and sometimes lay right in between the lateral and medial edges of the radius (Case 97, Fig. 55), or radially (Case 40, Fig. 56), or finally was observed in several places all along the frontal joint surface (Case 157, Fig. 58). Several times longitudinal fissures were verified, even proximally to the transverse fracture (Cases 17, 17*a*, and 118*a*, Figs. 59 to 62, and 64 and 65); in a couple of patients a violent splitting in both the dorso-ventral and lateral view (Cases 55 and 118*a*, Figs. 63 to 65).

The trauma was a fall—through slipping, from a ladder, in lift-cage, etc.—in all cases except Case 55 (Fig. 63), where the patient was run over by a cartload of wood (effect of direct violence), and Case 99 (Fig. 54), a chauffeur who got a blow from the rebound of the winch when cranking an automobile.

Besides the 12 cases reproduced, the following 16 cases belong to this group: Seven with about same appearance as Case 29, namely, 6, 31, 39, 77, 91, 94, and 123. One with about same appearance as Case 15, namely, 189. Three with about same appearance as Case 99, namely, 141, 145, and 202. Three with about the same appearance as Case 40, namely, 43, 102, and 135. One with about same appearance as Case 157, namely, 175. One with about same appearance as Case 17, namely, 41.

C. Fracture of the Radius Styloid Process (Fig. 66, Case 76; Fig. 67, Case 85; Fig. 68, Case 86; Fig. 69, Case 87; Fig. 70, Case 103).—To this group belong 14 patients of an age from twenty to fifty-six years of age (average age 35 and four-tenth years). In 3 of them (21.4 per cent.) even fracture of ulnar styloid process occurred. In one (Case 76, Fig. 66)—without visible ulnar lesion—a distal radio-ulnar diastasis was observed. Röntgenanatomically there was an intra-articular fracturing of a bone fragment, in frontal view of triangular shape and lying towards the lateral edge of the radius. The fracture line went from about the middle of the joint surface, slanting upwards and outwards to 1½–2½ cm. (in 11 patients 1¾–2¼ cm.) above the tip of the radius styloid process. In the lateral view the injury likewise appeared as a triangular fracturing, reaching in volar direction from about 1½ cm. above the joint level, obliquely, dorsally, and distally to the edge of the joint level (Case 87, Fig. 69), or a small bone fragment was seen only dorsally and distally broken off (Case 103, Fig. 70).

The fracture has in the majority of cases arisen through a fall. The

exceptions are patient 76 (Fig. 66), a chauffeur, who got a blow from the rebound of a winch when cranking an automobile, and Case 86 (Fig. 68) who was run over by a taxi, and Cases 54 and 72. Case 54 came underneath a wheelbarrow and was severely jammed from beneath by pressure in the thumb grip, whilst the elbow was pressed forcibly upwards and backwards against a plank. Case 72 had been jammed between a plank, against which his elbow was supported, and an iron beam in the flat of the hand, so that a heavy pressure was exercised in the direction of the forearm. A statement regarding the nature of the trauma in Cases 14 and 34 is lacking.

Besides the 5 cases reproduced by X-ray photographs there are the following 9 cases which belong to this group: Four cases closely resembling Case 76 (54, 60, 72, and 176). Five cases closely resembling Case 85 (14, 26, 34, 185, and 195).

D. Epiphysial Separation (Fig. 71, Case 27; Figs. 72 and 73, Case 116).— To this group belong six patients of an age from twenty-three to thirty-eight years (average age twenty-six and three-tenths years). In 4 cases even the ulnar styloid process has been injured; amongst these there occurs one patient (Case 116, Fig. 72) with distal radioulnar diastasis.

The fracture line lies 2 cm. above the joint in 4 cases, and 1½ and 1¾ cm. in one case each. According to the röntgen plate, it as good as falls together with the epiphysial line in Case 27 (twenty-four years of age), Fig. 71. Case 116 (twenty-three years of age) constitutes an intra-articular fracture, inasmuch as in ulnar direction a small bone fragment may be seen broken off farthest distally (Fig. 72). In the lateral-view picture the fracture begins in volar direction near the joint (appears broadest here) and proceeds in proximal direction obliquely upwards, dorsally inclined; there is also a fissure extending dorsally into the joint (Fig. 73).

The fracture originated through a fall, except in the case of two patients. The one of these (Case 27) had knocked his left flat hand against a rail whilst hit in the region of his elbow by a heavy cable-bearing falling down from above. The other (Case 164) was a chauffeur and had been injured in the characteristic manner through the rebound of a motor-car winch.

Hereto belong in addition to the two reproduced by X-ray plates Case 16 (fracture immediately above and as good as parallel with the epiphysial line), Case 46 (the fracture as good as in the old epiphysial line), Case 144 (the fracture in and partly contiguous to the epiphysial line), and Case 164 (the fracture almost completely falling together with the epiphysial line).

As will be seen, I have in this representation and as *chief principle* in the classification made use of the *state of development of the skeleton;* the fractures in individuals with incomplete ossification are collected into one group, fractures in those with complete ossification in another. The age limit is nineteen years, that period at which the epiphysial cartilage is customarily completely ossified (Pilcher, etc.; comp. Akerlund [literary notes]).

A summary of all the details in my material may here be in its place.

I will begin with the 54 fracture cases which *occurred at incomplete ossification* (Division I).

The anatomical appearance of most of these fractures was as the reproduced radiographs (Figs. 1–23) clearly show, on the one hand fairly identical; on the other hand, deviating somewhat from the type of the classical radius fracture.

In the 34 cases which together form the groups *A*, *B*, and *C* is often shown a lesion in both ulna and radius; in practically one-fourth of the cases is, according to röntgen, the ulna intact. The radius lesion lies about 1–5 cm. above the radiocarpal joint and appears, as a rule, as a transverse fracture line (Figs. 1 and 2, 13 cases, Group I*A*, or as an irregularity, or as a folding on the surface of the bone, "torus fracture" (Figs. 3 to 7), 12 cases, Group I*b*, or as a combination of both these variations (Figs. 8 to 14, 9 cases, Group I*c*). The appearance of the ulnar lesion shows the same variations, but in this wise, that in some particular case it sometimes deviates from the picture which the radius fracture in the same patient assumes.

In the remaining 20 cases there occurs either an epiphysial separation of the radius (Figs. 15 to 19, 16 cases, Group I*d*), or a typical radius fracture (Figs. 20 and 23, 4 cases, Group I*e*). There is nothing especially remarkable in the appearance of these injuries, except as to Cases 128, 156, 146, and 170. In the three first named—which are epiphysial separations—it is namely observed that the fracture line, in the same degree as it approaches the radius dorsally, turns off a bit up in the diaphysis, so that a small dorsal triangular bone fragment is broken off (Figs. 17 and 19). And in Case 170—which is a typical radius fracture—the epiphysial line appears broad and distinct, but the lesion of continuity in the bone has not taken place therein, but a little above (Fig. 21). I will return later on to these details (Pilcher calls to mind in his work the occurrence of similar phenomena in certain types of radius fracture).

The greater portion of my fracture material, *i.e.*, the 152 cases which concern individuals with complete ossification (Division II) has an entirely different anatomical character to those forms generally described.

The majority of them, 132 in number, constitute typical radius fractures (104 cases, Group II*A*) or typical radius fractures complicated by longitudinal fissures in the region of the wrist (28 cases, Group II*B*). The radius shows a fracture line going in a transverse or somewhat oblique direction, as a rule, 2–3 cm. above the radiocarpal joint, but with a variation in position of at least 1½ cm., at most 6½ cm., from there. Besides its mildest form, a simple transverse fracture without or with slight dislocation (Fig. 24), the injury appears in several, more or less severe variations. In a great number of cases it may be observed on both front- and side-view plates how the peripheral radial end is displaced, eventually also wedged in in radiodorsal direction in the char-

acteristic manner (Figs. 25 to 27, 29, 35, 37, 39 to 41, etc.). In some there occurs a comparatively slight splitting of the radial dorsal labrum (Fig. 35), or, taking it all round, in the nearest vicinity of the site of fracture (Figs. 26 to 31, 38, and 40). But not infrequently—the already mentioned 28 cases which form the Group II*B*—longitudinal fracturing of the radius right out to the radiocarpal joint has taken place (Figs. 49 to 65), which splitting sometimes even extends proximally to the transverse fracture (Figs. 59 to 62, 64 and 65). With regard to other details of interest, it should be pointed out, firstly, that Case 204, in which the side-view picture would seem to show that the dorsal periosteum was not torn at time of injury, but stood the test (Fig 25); secondly, Cases 134 and 113, where the front respectively side-view picture has a partial similarity to torus fracture (Figs. 28 and 46). The unusual course of the fracture line may be finally mentioned—in the frontal view something like an inverted S—to be observed in some patients (Figs. 42, 43, etc.; compare Fig. 21); likewise, also, the greater breadth in the fracture line volarally (Cases 11, 207, and 211, Figs. 33 and 34) and radially (Case 113, Fig. 145) in some other cases. Simultaneous injury to the ulna occurs in two-thirds of the fracture cases belonging hereto. It constitutes in the great majority of patients fracture at the apex or at the base of the styloid process, but consists in 3 cases (Cases 10, 104, and 200) of a transverse or oblique fracture higher up in the ulna itself at about the same height as the radius injury, about 1 cm. above the ulnar styloid process (Figs. 47 to 49). Besides the ulna lesion, the X-ray plate shows in 7 cases, as far as can be judged, an abnormally wide diastasis in distal radioulnar connection, which complication, moreover, seems to have occurred in 8 cases of radius fracture without accompanying injury to the ulna (see Figs. 24, 36, 50, and 54).[5]

There still remain amongst this category of radius fractures two lesser groups of cases, embracing fracture of the radial styloid process together with epiphysial separation.

Sole fracture of the radial styloid process occurs in 14 patients (Group II*C*). According to X-ray plate, there is an intra-articular fracturing of a bone fragment, of triangular shape in frontal view and lying towards the lateral edge of the radius (Figs. 66 to 68). The fracture line proceeds from the region of the middle of the joint surface obliquely upwards and outwards to about 2 cm. above the apex of the radius styloid process; the lateral-view picture shows a corresponding appearance (Figs. 69 and 70). A slight splitting is observed in a couple of cases (Figs. 67 to 69). Simultaneous fracture in ulnar styloid process occurs in practically one-fifth of the patients. One of these (Case 76, Fig. 66) seems to show an abnormal diastasis in the distal radio-ulnar connection.

A more or less typical epiphysial separation of the radius is verified in 6 patients (Group II*D*, Figs. 71 to 73). Out of them, 4—that is to say, two-thirds—have simultaneous ulna fracture. In one case (Fig. 72) there

I. FRACTURES IN INDIVIDUALS WITH INCOMPLETE OSSIFICATION

A. TRANSVERSE FRACTURE OF RADIUS AND ULNA

FIG. 1.—Case 129.

FIG. 2.—Case 129.

B. TORUS FRACTURE OF RADIUS (EVENTUALLY WITH SIMULTANEOUS ULNA LESION)

FIG. 3.—Case 100.

FIG. 4.—Case 100.

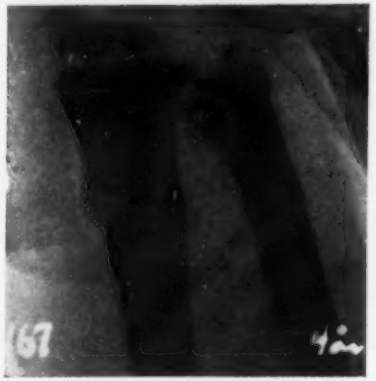

FIG. 5.—Case 167.

B. TORUS FRACTURE OF RADIUS (EVENTUALLY WITH SIMULTANEOUS ULNA LESION)—*Continued*

FIG. 6.—Case 178.

FIG. 7.—Case 178.

C. TRANVERSE FRACTURE WITH SIMULTANEOUS VISIBLE CORTEX TORUS

FIG. 8.—Case 111.

FIG. 9.—Case 111.

FIG. 10.—Case 131.

C. TRANSVERSE FRACTURE WITH SIMULTANEOUS VISIBLE CORTEX TORUS.—*Continued*

FIG. 11.—Case 131.

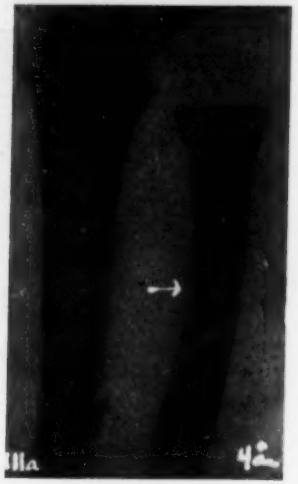

FIG. 12.—Case 111*a*.

FIG. 13.—Case 131*a*.

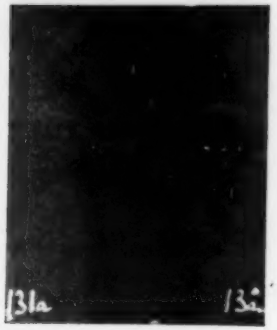

FIG. 14.—Case 131*a*.

D. EPIPHYSIAL SEPARATION

FIG. 15.—Case 83.

FIG. 16.—Case 156.

FIG. 17.—Case 156.

D. EPIPHYSIAL SEPARATION.—*Continued*

FIG. 18.—Case 128.

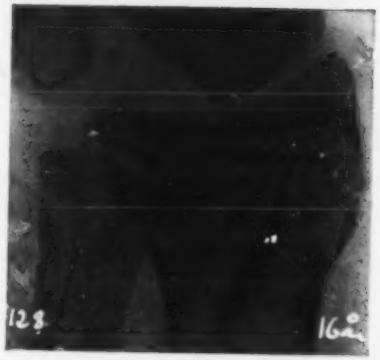

FIG. 19.—Case 128.

E. TYPICAL RADIUS FRACTURE.

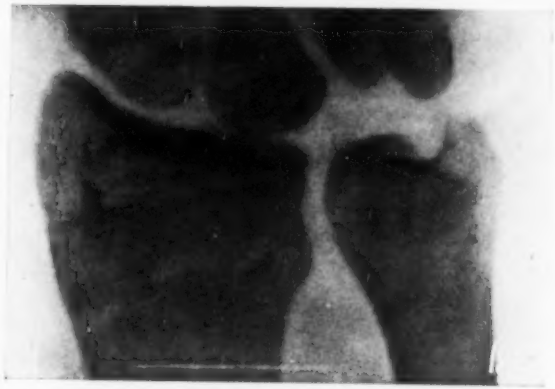

FIG. 20.—Case 114.

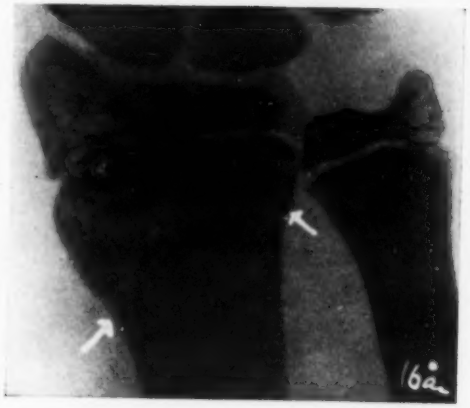

FIG. 21.—Case 170.

E. TYPICAL RADIUS FRACTURE.—*Continued*

FIG. 22.—Case 151.

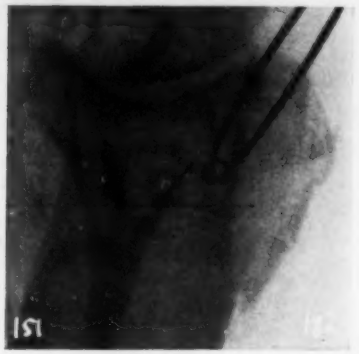

FIG. 23.—Case 151.

II. FRACTURES IN INDIVIDUALS, WITH COMPLETE OSSIFICATION

A. TYPICAL RADIUS FRACTURE

FIG. 24.—Case 204.

FIG. 25.—Case 205.

FIG. 26.—Case 130.

FIG. 27.—Case 130.

A. TYPICAL RADIUS FRACTURE.—*Continued*

FIG. 28.—Case 134.

FIG. 29.—Case 71.

FIG. 30.—Case 24.

FIG. 31.—Case 67.

FIG. 32.—Case 168.

FIG. 33.—Case 207.

A. TYPICAL RADIUS FRACTURE.—*Continued*

FIG. 34.—Case 211.

FIG. 35.—Case 115.

FIG. 36.—Case 90.

FIG. 37.—Case 209.

FIG. 38.—Case 52.

FIG. 39.—Case 52.

A. TYPICAL RADIUS FRACTURE.—*Continued*

FIG. 40.—Case 42.

FIG. 41.—Case 42.

FIG. 42.—Case 7.

FIG. 43.—Case 53.

FIG. 44.—Case 53.

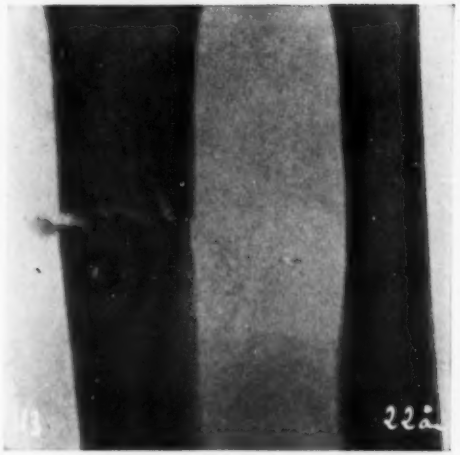

FIG. 45.—Case 113.

A. TYPICAL RADIUS FRACTURE.—*Continued*

FIG. 46.—Case 113.

FIG. 47.—Case 10.

FIG. 48.—Case 104.

FIG. 49.—Case 104.

B. RADIUS FRACTURE WITH LONGITUDINAL FISSURES, TOO, EXTENDING INTO THE RADIOCARPAL JOINT

FIG. 50.—Case 159.

FIG. 51.—Case 29.

FIG. 52.—Case 210.

FIG. 53.—Case 15.

FIG. 54.—Case 99.

FIG. 55.—Case 97.

B. RADIUS FRACTURE WITH LONGITUDINAL FISSURES TOO, EXTENDING INTO THE RADIOCARPAL JOINT.—*Continued*

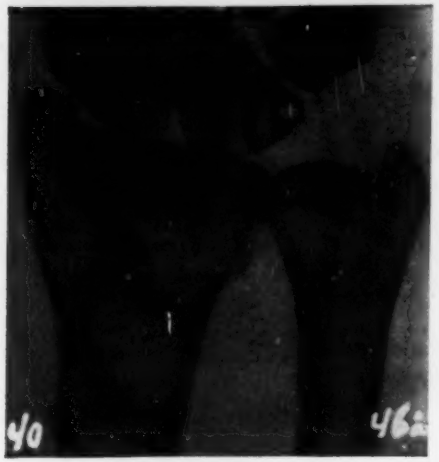

FIG. 56.—Case 40.

FIG. 57.—Case 40.

FIG. 58.—Case 157.

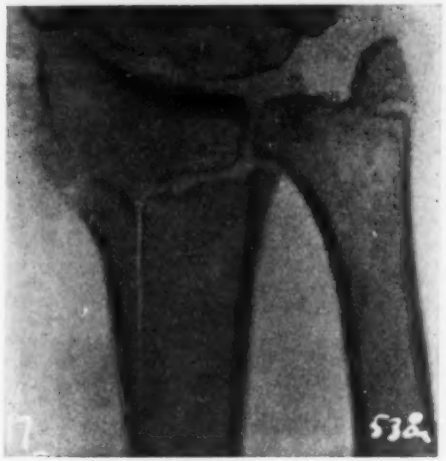

FIG. 59.—Case 17.

FIG. 60.—Case 17.

FIG. 61.—Case 17*a*.

FIG. 62.—Case 17*a*.

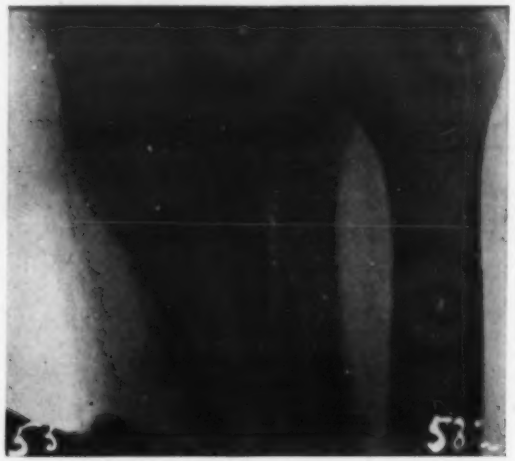

FIG. 63.—Case 55.

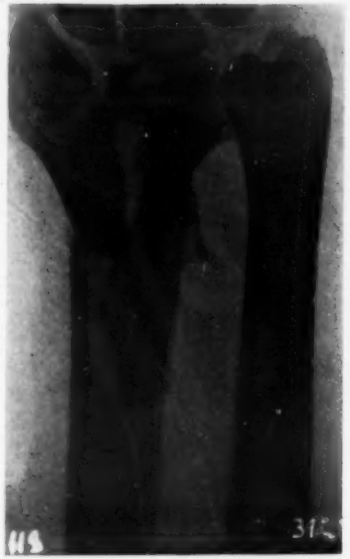

FIG. 64.—Case 118*a*.

FIG. 65.—Case 118*a*.

C. FRACTURE OF THE RADIUS STYLOID PROCESS

FIG. 66.—Case 76.

FIG. 67.—Case 85.

FIG. 68.—Case 86.

FIG. 69.—Case 87.

FIG. 70.—Case 103.

D. EPIPHYSIAL SEPARATION

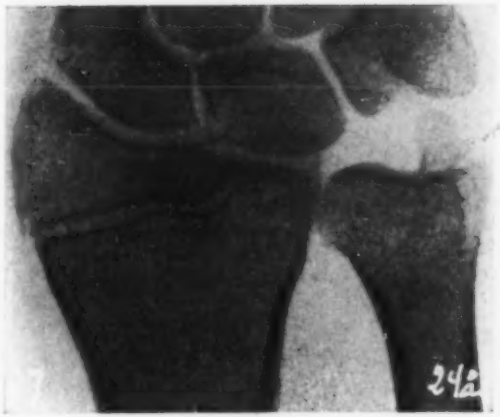

FIG. 71.—Case 27.

FIG. 72.—Case 116.

FIG. 73.—Case 116.

RADIUS FRACTURES, EXPERIMENTALLY PRODUCED ON CADAVERS

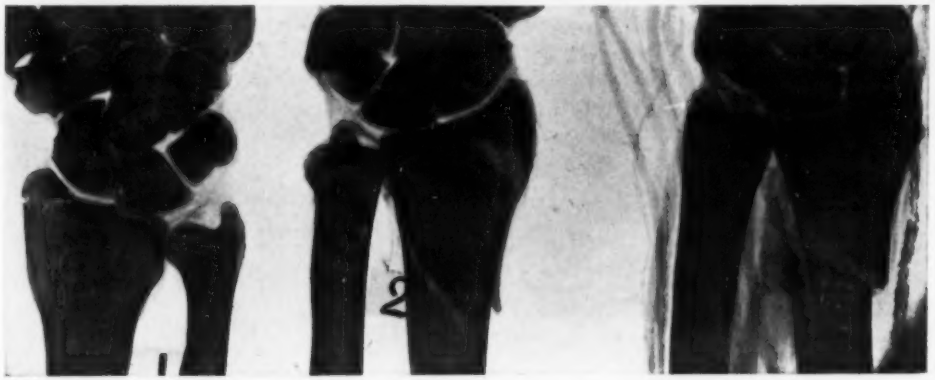

FIG. 74.—Cases 1, 2, 3.

RADIUS FRACTURES, EXPERIMENTALLY PRODUCED ON CADAVERS.—*Continued*

FIG. 75.—Cases 1, 2, 3.

SIDE VIEW OF THE RADIOCARPAL REGION FROM A NORMAL HAND

FIG. 76.—Hand pronated.

FIG. 77.—Hand supinated.

occurs, as far as one can judge, an abnormally wide distal radio-ulnar connection. Röntgenologically it may, moreover, be pointed out that the fracture line does not a single time quite join with the epiphysial line. The detail—which should be seen in connection with the already mentioned occurrence of juxtaepiphysial radius fracture in a sixteen-year-old individual in Case 170 (Fig. 21)—is remarkable, but earlier indicated by Ollier and Pilcher. The former, even, is of the opinion that a bone injury of the kind in question seldom, if ever, goes into the cartilage itself, but, on the contrary, into the spongiose bone tissue lying close beside it, whereof thus at least something of it always remains adhering to the epiphysial cartilage.

A closer consideration of the particulars here given should clearly prove that it was both natural and right to divide up my material in the fashion done with reference to forearm fracture in the region of the wrist. It is quite evident that there is a difference in the *anatomical character* of the same, according to if it is a question of individuals under or above the age limit for the completion of ossification. The trauma—in quite the majority of patients a fall on the prone and extended hand—which a child or young person has met with has most often occasioned a more or less transversal fracture in the diaphysis of the forearm, near the wrist, about on the same level of both bones; in scarcely 30 per cent. of the cases has an epiphysial separation set in, and in only about 7 per cent. a so-called typical radius fracture. In individuals above the age of nineteen years, on the contrary, a corresponding violence has with very few exceptions led to a more or less severe typical radius fracture, whilst in only some few cases has it been associated with an equally highly situated transverse or oblique fracture of the ulna, but otherwise has very often been accompanied by fracture of the ulnar styloid process; in a frequency of about 9 per cent. was there a fracture of the radius styloid process at hand, in scarcely 4 per cent. could an epiphysial separation of the radius be recognized.

My division of the fractures in question obtains further authorization inasmuch as it offers the possibility of, as far as one can find, a fairly uniform comprehension of the *manner of origin and mechanism* of these injuries.

I will once again begin with the fractures which have occurred in the case of not yet completed ossification. By way of exception—as, for instance, in Case 170 (Fig. 21, Group I*E*)—the clinical data already give here a decided suggestion of the nature of the fracture. The patient mentioned had been injured through what for a radius fracture is a very unusual violence, insofar as he was trampled on the dorsum of his forearm by a horse; he had thus been exposed to a trauma whose action is typical for the origin of certain kinds of flexion fracture (compare the sketch to the left in Fig. A).

It is, however, more often the röntgenological details which first con-

vey information of value for the classification of the fracture. Of special interest in this respect are those cases in which radius shows, firstly, a cortex torus (folding) on the surface, and secondly, a fracture line straight through the bone (Group I*C*, Figs. 8 to 14). Each or both of these details appear, namely, together with an occasionally occurring distinct concavity or angular curving of the fracture area, as characteristic for the majority of fractures belonging to the head group (I). We recognize in the cortex torus (folding) the simplest and mildest effect of a concentrating violence, acting essentially in the longitudinal direction of the extremity —stauchung (Kohl, Quervain, Iselin, Burnham, etc.)—on the juvenile, fairly elastic bone. In the transversal or oblique fracture fissure at hand a similar and previous trauma may be traced. For, in the first place, the fracture is in several cases broader, *i.e.*, there is a larger diastasis, at the edge of one bone than at the other (Figs. 8 and 12, Cases 111, 111*a*, and 191), and, in the second place, there is sometimes a curving of the bone (dislocatio ad axin) with convexity in that direction where the fracture line is broadest (Figs. 9 and 12, Cases 111, and 111*a*). The radiograph has, in other words, that appearance which is to be expected after a trauma, the effect of which is shown in the sketch to the right in Fig. A. The bone has evidently been compressed from end to end, momentarily bent, and began to break on the very spot of the vertex of the temporary strain—*i.e.*, the convexity. Röntgenologically the effect is that of a combination of compression (stauchung) and flexion fracture. The closely connected genetic relationship of the cortex stauchung with the transverse or oblique fracture in question is already evinced by those cases where radius shows the former injury and ulna the latter (Figs. 3 and 5, Cases 20, 100, 167,[6] 194, 186, and 187). But it is most clearly visible in those cases where both kinds of bone lesions are simultaneously traced on the same bone. There it is unmistakably to be seen on the plate how a transversal breakage in the bone has begun on the ulnar (medial) and volar side in the ulna and radius whilst a cortex stauchung has arisen radially (Case 132). Or—Case 111 (Figs. 8 and 9)—how a transversal fracture of the radius has begun on the volar and radial side, whilst the ulna was forcibly bent so that a dorsal concavity and a dorsal and ulnar cortex stauchung have taken place. Analogous conditions are demonstrated by the Cases 131, 111*a*, and 131*a* (Figs. 10 to 14). In all of them the folding (the torus) lies in the cortex on that side of the bone which is turned away from that where the fracture line begins, or is widest.

In the light of this argument, the cases in Group I*B* (Figs. 3 to 7) are fully comprehensible. The longitudinal compression, at the age in question, of the fairly elastic bone of the forearm has caused a temporary flexion. But this has not gone so far that a transverse fissure going through the whole continuity of the bone and clearly visible on the X-ray plate has arisen—or, at most, only arisen in the ulna (compare Fig. 5, Cases 20, 194, 57, 167, etc.)—but only occasioned a remaining unevenness

FIG. 78.—Clear lateral view (with hand in dorsal flexion).

FIG. 79.—Lateral view with the dorsal-flected hand somewhat supinated.

FIG. 80.—Photograph of the volar surface (hand in dorsal flexion.)

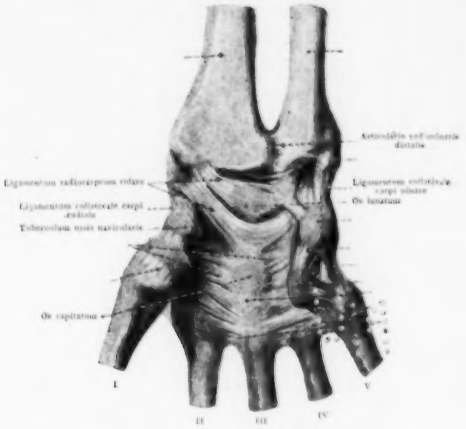

FIG. 81 (from Spalteholz).—The volar ligaments of the carpal joint.

in the cortex of the radius on the spot during the trauma of the momentarily deepest part of the concavity. The seat of the cortex stauchung will consequently be, since the trauma is often brought about by a fall on vola manus, as a rule, on the dorsal or dorsal-radial side (see Figs. 3 to 5, Cases 100, 101, 147, 167, 181, 194, etc.), If, as in Cases 178, 186, and 187, where the patient has been upset whilst cycling, the injury has been brought about in this wise, that whilst trying to save himself with his hand outstretched in volar direction, *i.e.*, with dorsum manus—which patient 178 himself states as having done—then the cortex stauchung will be on the volar, radial, and ulnar side (Figs. 6 and 7). It is less easy to find out röntgenologically the mechanism of origin in the cases in Group I*a*, the pure transverse fractures without visible cortex torus (folding). All the clinical statements at hand should, however, through their agreement in point of principle with the cases in Group I*b* and *c*, be entitled to be compared with these. That there can at least in part have been circumstances—in technical or other respects—which have had some influence with regard to the appearance of the X-ray plate is evinced by Case 197, for instance. The injury was in this case occasioned by a powerful blow in the longitudinal direction of the forearm; it is quite evident, according to the anamnestics, that the patient whilst sledging drove his right hand so hard against a tree that his arm came into a rectangular position. But the radiograph shows—after replacement—that in spite of this, only a transverse fracture ensued, without either special cortex change or dislocatio ad axin.

My material consequently seems to entitle to the belief that *the forearm fractures in the region of the wrist, which are the usual ones for individuals with incomplete bone development* (Group I*a* to *c*), *are, as a rule, with regard to manner of origin, compression fractures, or, a combination of compression and flexion fractures.* The minority of cases of epiphysial separations and typical radius fractures (Groups I*d* and *e*) which in my classification with regard to age have been placed in this category might, in my opinion, in a discussion on the theory of the genesis of the fracture, be suitably placed together with the epiphysial separations and typical radius fractures which occur in and are characteristic for persons with complete ossification. The reason that the trauma, which, on the whole, has been identical in nature, in the former (Groups I*d* and *e*) has shown in point of principle similar anatomical variations to the injuries in the latter (Group II), probably lies in the fact that the solidity of the skeleton has been about the same—in spite of the differences in age.

And it is in reality interesting to notice in this connection how the age of the patients is divided up within the different groups in the fracture category I. As the table demonstrates, the average value shows a steady rise for them in the order that the fractures are spoken of. Transverse and torus fractures in Groups I*a* to *c* occur in persons at an average age of scarcely ten years, epiphysial separations in those at fourteen

years, and the typical radius fracture at seventeen and five-tenth years. The occurrence of the first-named fractures, which are diaphysis injuries, in the youngest of all originates, no doubt, in the fact that the distal ossification centre at this stage of bone development, before the age of twelve, is so small—Case 131 (Fig. 10) constitutes an example of an exception—that it scarcely offers even mechanical possibilities for the genesis of an epiphysial separation or a typical radius fracture (see Figs. 5, 8, and 12; compare Pilcher, p. 12); the strain of the trauma will therefore essentially assert itself in the diaphysis. But in the same degree as the bone growth approaches completion and the skeleton of the forearm assumes a greater likeness to that of the adult, so will the risk of the lower radius epiphysis reacting in the same manner as is the case with the latter against the trauma, become greater; and, at the same time, when a strong cortex, etc., is developed in the diaphysis, *i.e.*, its strength improved, so will the latter's possibility of sustaining the trauma without fracturing ensuing be increased.

There remain radius fractures in persons with complete ossification (Group II). In their case—on an attempt to make an analysis of the kind here in question—it shows even as in the case of fractures before the completion of ossification what a faulty guidance the clinical analysis gives, as a rule, with relation to a reliable exposition of fracture mechanism.

A brilliant example of this circumstance is offered by the so-called chauffeur fractures, numbering five in all. The trauma has here—from what one has reason to suppose—been of much about the same nature; the rebound of the winch on the chauffeur's attempting to start the motor car, *i.e.*, a heavy blow operating in the dorsal and proximal direction of the forearm. But the effect thereof has in different cases been very different. Two of the patients received a typical, transversal radius fracture (Cases 110 and 113, Figs. 45 and 46), one, in addition, contracted an intra-articular longitudinal splitting of the radius (Case 99, Fig. 54), another got a radius styloid process fracture (Case 76, Fig. 66), and one finally epiphysial separation (Case 164). All types of fractures occurring within Group II have consequently been represented as a resulting condition of one and the same trauma. The X-ray picture makes it probable that one of the fractures (Case 113, Figs. 45 and 46), by reason of a greater breadth on the radial than on the ulnar side of the fracture line, together with a suggestion of dorsal concavity (dislocatio ad axin), is a case of compression fracture—perhaps more correctly a combination of compression and flexion fracture—according to the drawing to the right in Fig. A; but for the remaining four cases can the X-ray pictures scarcely be said to give any similar or obvious guidance.

A priori it lies undeniably nearer to hand to suppose that if the trauma causing the injury be somewhat about the same, the mechanism of the forearm fracture in the region of the wrist should most often be in point of principle similar at the period of complete ossification of the skeleton

and at incomplete; that, in other words, even in the adult, the injury here concerned would, as a rule, be a compression fracture or a compression-flexion fracture, and in point of fact, much would seem to prove that such is the case.

In Group II several cases occur where the radiograph illustrates that the fracture has been brought about by a powerful compression from end to end in the longitudinal direction of the forearm, according to the sketch to the right in Fig. A. Sometimes the side-view picture shows—absolutely in analogy to what has been demonstrated in several cases in Group I—a greater breadth on the volar (Figs. 33, 34, and 39) or radial (Fig. 45) side of the fracture line than dorsally ulnarally. Sometimes the X-ray pictures show details which best coincide with the presumption that the bone injury has been occasioned by a longitudinal compression, the effect of *coup et contrecoup*. I hereby allude partly to the splitting of the radial dorsal labrum which is observed in solitary cases (*e.g.*, Case 115, Fig. 35), and partly to the longitudinal fissures extending into the radiocarpal joint in a whole group of injuries (Group II*b*, at least 28 cases). The reproduced röntgen pictures (Figs. 50 to 65) should fully illustrate that the fracture mechanism of these cases may easily be brought into agreement with the description of the effect of longitudinal compression on the long tubular bone in adults, which I have above cited from Zuppinger and which is schematically demonstrated in Fig. B. A further consideration will also give one to understand how difficult—in certain cases (*e.g.*, Cases 55 and 118*a*, Figs. 63 to 65) impossible—it is to imagine their origin in accordance with the theories on wrench fracture or, in fact, any other kind of fracture than compression fracture.

If we, on the contrary, furthermore take into consideration the fact that in none of my radius fractures is there a case to be met with wherein the effect of the trauma is entirely confined to a fracturing of the radial volar labrum beginning in volar, and proceeding in oblique distal dorsal direction towards the radiocarpal joint, so is even that fact rather remarkable. Such a type of fracture would seem to have been at least a somewhat usual recurring phenomenon if the injury were as regards genesis to be interpreted essentially as a wrench fracture.

In general, the most important anatomical conditions for the genesis of wrench fracture of the radius are described as lying partly in the radial volar labrum projecting markedly in volar direction (see Figs. 34, 46, and first and foremost 76), and partly the strong ligament apparatus, essentially ligamentum radiocarpeum volare (Fig. 81), which emanates from os capitatum and other carpal bones and inserts volarally in the radius. Pilcher, among others, has schematic, very demonstrative drawings of the same. If one, however, carefully inspects an upper skeletted extremity, it will be seen that the volar distal radius area, which in certain lateral-view pictures is so well portrayed as a projecting volar labrum, constitutes the ulnar (medial) radius part (see Figs. 79 and 80) which in comparison with the radial (lateral) part of the radius epiphysis con-

stitute but in a very subordinate degree a hold for the ligament in question (Fig. 81). The existence of strong ligaments which are said to insert on the labrum mentioned (on the ulnar side of radius) would therefore seem in point of fact to be more of a schematic construction on the part of the majority of authors rather than a reality. The strongest part of the volar radiocarpal ligament inserts radially (laterally) in the radius, and a strain on the distal volar end of the radius, such as might be thought to occasion a wrench fracture, should consequently, from a theoretical point of view, lead more especially to a wrenching off of the radial styloid process.

The question then arises voluntarily: Is there no visible means or probability of such a fracture arising clinically? The answer must be in the affirmative. A reference to Group II*C*, radial styloid process fracture (Figs. 66 to 70; 14 cases), in my material constitutes hereby sufficient grounds. The nature of the trauma is in the case of two of these patients rather remarkable; the one (Case 54) had had a wheelbarrow pass over him and thereby became severely jammed by pressure in the grip of the thumb, whilst his elbow was pressed hard against a plank; the other (Case 72) had been jammed between a plank against which his elbow was resting and an iron beam right in the flat of his hand. The conditions for a simple wrench appear here to be fairly discernible.

Although conscious of the fact that bone and ligament tissue after death (post-mortem) cannot be considered without more ado to react against violence in the same way as during life (intra vitam), I have yet endeavored to ascertain what type of radius fracture one can produce on a corpse which is arranged for by different methods. Only once—in the course of twelve experiments—did I succeed in producing a lesion of similar type to Group II*c*. It was a question of a skeleton of an elderly individual from which the muscles had been dissected, and only the ligaments were left. The flat hand of the skeleton was placed on a table and pressed heavily against the support by dorsal breaking of the forearm (hyperextension of the hand). The consequence was that already with but very moderate violence a perceptible cracking and transverse fracturing of the radial styloid process scarcely one cm. above the apex of this apophysis was noticeable (Figs. 74 and 75). Röntgenologically the fracture very much resembles the clinical fractures in Group II*C*. In all the rest of the corpse experiments it was, however, impossible for me, with the assistance of either the one or the other methods of violence, to produce a similar fracture type. The result was either a tearing of the ligaments or tension, or there ensued one of the two other types of fracture which are found reproduced in Figs. 74 and 75. The fracture in Figs. 74 and 75 was produced on a forearm on which only the ligaments were left. The flat hand of the skeleton was placed on a stone floor with the forearm supported against a wall at an angle of 45° to the floor. A heavy blow with a broad hammer was exercised on the back side of the forearm immediately above the wrist (also the same mechanism for the trauma as in

the drawing to the left in Fig. A). The fracture line takes its course in an oblique, proximal, dorsal, and somewhat radial direction, its uppermost part lies 5½ cm. above the apex of the radial styloid process (Fig. 74). The lateral-view picture seems to show that the diastasis between the fractured ends is broader in volar than in dorsal direction—as the case should be with a flexion fracture. Something akin to this fracture type in the röntgenanatomical sense of the word is Case 53 (Figs. 43 and 44, a fifty-nine-year-old man, who had fallen down sideways and tried to save himself with his hands as he was endeavoring to avoid an automobile) and, although in lesser degree, Case 7 (Fig. 42, a twenty-five-year-old man, wound unknown). The fracture in Figs. 74 and 75 concerns a forearm where,

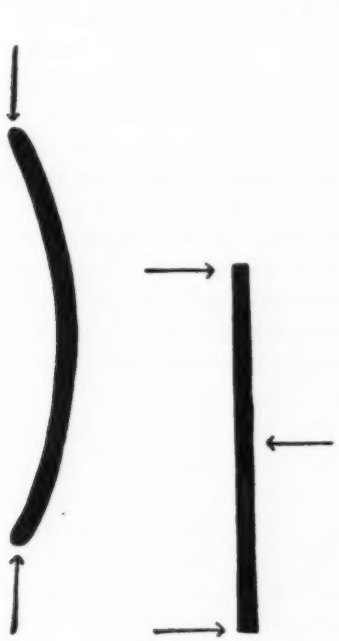

Fig. A.

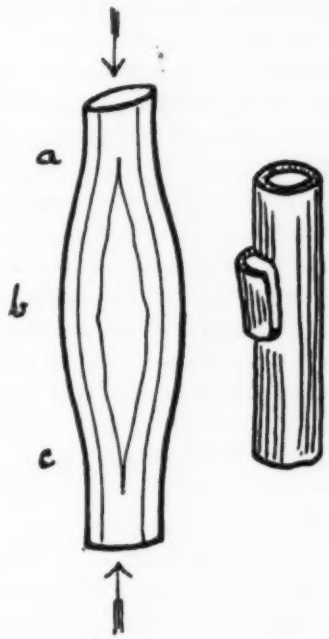

Fig. B.

besides ligaments, even muscles and tendons—dissected up—were found remaining. The trauma was produced thereby that the hand with vola manus upturned was squeezed in the drawer of a table which was all but shut, the distal end of the navicular bone was hitched up at the top of the edge of the table, the forearm was grasped in the region of the elbow and was broken forcibly downwards. The effect was a somewhat oblique, transversal fracture 5 cm. above the radiocarpal joint. The lateral-view picture with its greater breadth on the volar than on the dorsal side of the fracture line reminds one most of a flexion fracture. The type resembles somewhat the fracture in Figs. 45 and 46 (Case 113, chauffeur fracture). I did not a single time succeed in producing a fracture on a corpse by a direct imitation of Nélaton's postmortem experiment. A powerful blow of the hammer on the upper end of the vertically placed

skeleton of the forearm, with the hand of the same dorsally extended and vola manus resting on a hard support, only led to a breaking (tearing) of the radiocarpal ligaments. The reason of this was probably the fact that the dead bodies at my disposal for this particular experiment were not of sufficiently recent date.[7]

A summary of what has been stated concerning the genesis-mechanism of forearm fracture in the region of the wrist, *i.e.*, of the usual radius fracture in its various forms, based upon my own material, amounts to the following:

I. A group—II*B*—comprising 28 or certainly more cases, should undeniably constitute compression fractures. These injuries can scarcely have originated otherwise than by a powerful blow in the longitudinal direction of the extremity (coup et contrecoup). A comminute fracture with long, longitudinal fissures extending out in the joint cannot very well have occurred through wrenching. The latter necessarily appear to have originated primarily—that they really do so is demonstrated by such cases as, for instance, Case 159 and 118*a* (Figs. 50, 64, and 65), where there is an absence of transverse fracturing or where the same retires into the background. The indications of Wolkowitsch and others concerning this latter moment seem to me to be well founded; likewise his suggestion that the area for the radius fracture—that part of the bone where the strong compact of the diaphysis changes into a thin putamen on the extremely spongiose epiphysis which is much broader in extent (Figs. 50, 51, etc.)—on acceptance of this theory is best understood.

II. A group—II*C*—comprising 14 cases, may in consideration of the expansion of the ligament apparatus and the position of the fracture line be interpreted as wrench fracture. The anamnestic statement of the nature of the trauma gives here just as little uniform guidance of any real value as is the case, as a rule, for the rest of the groups, and this so much the less, as amongst the 14 injuries mentioned cases are also met with (chauffeur fractures) where the violence must rather be thought to have been a longitudinal compression and which in consequence with regard thereto are analogous with injuries which röntgenanatomically show themselves to be compression fractures or compression-flexion fractures.

III. For the large groups of fractures—Group II*A*, 104 cases—which have the most usual simple character of the so-called typical radius fracture, there is nothing of either clinical or anatomical moment which conclusively argues in favor of either compression or wrench mechanism. Such an injury (Case 170) belonging to Group I*e* has, however, obviously arisen through a violence, the effect of which is generally a typical flexion fracture, thus an injury closely related to a compression fracture (compare Fig. A); fractures effected on a corpse by similar means of violence have besides in a couple of cases practically obtained the appearance of typical radius fracture.

IV. *Ex analogiam* it lies near to hand to presume that the majority of radius fractures in adults originate as compression fractures, since that

fracture form which obviously arises after a similar trauma in children and the young most often has the character of a compression (so-called stooking) fracture or compression-flexion fracture.

The classification now under consideration of fractures of the forearm in the region of the wrist has established the following:

I. The *anatomical nature* of these injuries is to a very great extent dependent upon the stage of development in that part of the skeleton which has sustained the trauma in question. In the case of an individual with incomplete ossification, the fracture most often assumes the character of transverse or torus fracture of the diaphysis of both bones of the forearm. In an individual with complete ossification—*i.e.*, above nineteen or twenty years of age—the injury assumes, on the contrary, the appearance of a so-called typical fracture of the lower radius epiphysis, with, or sometimes without, simultaneous lesion of the ulnar styloid process.

II. With regard to the *genesis mechanism*, the majority of these fractures, judging by the radiographs, would seem in the case of individuals with incomplete ossification to be compression fractures (or compression-flexion fractures). And even for other reasons, there is all authority for interpreting the typical radius fracture also—which is the equivalent at a later age to the transverse and torus fractures in children—as being, generally speaking, a compression fracture, although the X-ray anatomical details do not lend conclusive support to such an interpretation in the same degree for the former as for the latter.

REFERENCES

Reference to notes given at foot of page in the proof, and page number of notes in the translation:

	Page No.	Ref No.
British Medical Journal, 1879, July 12th, p. 39 (cit. Pilcher)	1	1
Oral lessons, 1839, T 1, p. 143 (cit. Wolkowitsch. See also Hennequin)	1	1
Cit. Lecomte: New researches concerning indirect fractures of the base of radius. General principles of medicine, 1860, p. 654 (cit. Wolkowitsch)	1	2
Cit. Malgaigne: Treatise on bone fractures. Russian translation, 1850, p. 616 (cit. Wolkowitsch and Kranz)	1	3
Supplement to the treatise on bone fractures, 1853, p. 93 (cit. Wolkowitsch)	1	4
Cit. Kranz	1	5
The cases here even as in the material at large have first been collected in the different groups, with the guidance of the appearance of the radiographs; not until afterwards have the statements regarding patients' age, etc., been set up	2	1
Measured up—here as regarding all radius fractures in the material—on the Röntgen plates—in reality lying somewhat nearer the joint	2	2
Two cases observed by me from that period which the material embraces are here excluded; the one a 25-year-old man; the other a 22-year-old woman. The injury consisted solely of ulnar styloid process fracture	3	1
Compare note on table	4	1
It is undeniably difficult occasionally to verify with certainty as to whether the interval between the distal ends of radius and ulna, sometimes		

seen on Röntgen pictures, is pathological or not, especially as the plate put in during the process of photographing may have some influence. And unfortunately, the uncertainty is by no means always to be overcome by relying on purely clinical statements, since so many—eight in all—of the cases in question have not been examined afterwards. In six of those belonging to group II and afterwards examined, it was, however, ascertained three-quarters to one year after the injury, that slight or severe trouble was still experienced in the hand, whilst three felt nothing more whatsoever of their old injury... 5 1

It must be acknowledged that case 167 could just as well have been classed with Group IC as with group IB. Since the stauchung on the radius is the most prominent on the Röntgen plate and no transverse lesion is distinctly seen going right through the whole bone, it has, however, been relegated to the latter group 6 1

Regarding material for post-mortem experiments, I owe a debt of gratitude to Professor E. Müller, in whose department the experiments were carried out 8 1

LITERATURE

Burnham: Fractures about the wrist in childhood and adolescence. ANNALS OF SURGERY, 64, 1916, p. 318.

Destot et Gallois: Recherches physiologiques et expérimentales sur les fractures de l'extrémité inférieur du radius. Rev. de Chir., 18, 1898, p. 886.

Helferich. Fracturen und Luxationen, 1903, p. 205.

Hennequin: Considérations sur le mécanisme, les symptomes et le traitément des fractures de l'extrémité inférieure du radius consécutives aux chutes sur le poignet. Rev. de Chir, 1894, No. 7 et 9.

Iselin: Stauchungsbrüche der kindl. u. jugendl. Knochen, Beitr. z. kl. Chir., 79, 1912, p. 440; Korrespondenzbl. f. schweiz. Ärte, 42, 1912, p. 690.

Kahleyss: Beiträge z. Kenntnis der Fracturen am unteren Ende des Radius. Deutsche Zeitschr. f. Chir., 45, 1897, p. 531.

Kaufmann, C.: Diagn. u. Behandl. der subcut. Radiusfraktur am Handgelenke. Deutsche Zeitschr. f. Chir., 116, 1912, p. 140.

Krantz: Üb. d. Behandl. des typ. Radiusbruches. Deutsche Zeitschr. f. Chir., 106, 1910, p. 270.

Kuhn: Der Mechanisms der Fract. radii typ. Deutsche Zeitschr. f. Chir., 63, 1902, p. 596.

Löbker: Über d. Entstehungsmechanismus der typ. Radiusfraktur. Deutsche med. Wochenschr., 1885, Nr. 27.

Müller, Ernst: Über subperiostale irreponible Fracturen des Vorderarmes, Beitr. z. kl. Chir., Bd. 76, H 1, Ref. Zentralbl. f. Chir., 1912, p. 760.

Pilcher: Fractures of the lower extremity or base of the radius. ANNALS OF SURGERY, 65, 1917, p. 1.

Troell: Über die Behandlung der Radiusfraktur. Arch. f. kl. Chir., 101, 1913, p. 511. Nord. med. ark., 1914, i, Nr. 24, p. 1.

Troell: Über Knochenbrüche am Unterschenkel. Arch. f. kl. Chir., 111, 1919, p. 915.

Wolkowitsch: Einige Daten üb. d. Mechanismus der Entstchung der Radiusfrakturen, etc., Arch. f. kl. Chir., 76, 1905, p. 917.

Vulliet: Les fractures de l'extrémitié inférieure du radius chez l'enfant. Semaine médicale, 34, 1914, p. 277.

Zuppinger und Christen: Allgemeine Lehre von den Knochenbüchen. Kurzgefasste Lehre v. d. Knochenbüchen, von Quervain, u. a., 1913, p. 1.

Åkerlund: Entwicklungsreihen in Röntgenbildern von Hand, etc., im Mädchen-und Knabenalter, Fortschr. a. d. Gebiete der Röntgenstrahlen, Erg. bd. 33, 1918.

TABLE OF CASES OF RADIUS FRACTURES IN THE REGION OF THE WRIST

Fracture type	With incomplete ossification			With complete ossification			Remarks
	Number of cases	Average age, years	Number of cases with simultaneous fracture of ulna	Number of cases	Average age, years	Number of cases with simultaneous fracture of ulna	
Transverse fracture of radius and ulna (see rem.)	13	8	10(=77%)[1]				[1]In three cases besides probable ulna fracture
Torus fracture of radius (ev. with simultaneous ulna lesion)	12	10	6(=50%)				
Transverse or oblique fracture with simultaneous visible cortex torus	9	11	8(=90%)				
	34	9.5	24(=70.6%)				
Epiphysial separation of radius	16	14	3(=18.7%)	6	26.3	4(=66%)	
Typical radius fracture	4	17.5	1(=25%)				[2]The figure is in reality surely too low; in, for instance, cases 5 and 204, which are classed with the immediate preceding group, it is probable that the radiograph shows a longitudinal fissure ending in the joint, proceeding from the transverse fracture.
Radius fracture with longitudinal fissures out in joint	.....	.....	.....	104	48.8	64(=61.5%)	
				28	48.4	18(=64.3%)	
				132		82(=62.1%)	
Fracture of radial styl. process	.....	.....	.....	14	35.4	3(=21.4%)	
	54	.....	28(=51%)	152	.....	89(=58.5%)	

=206 cases (whereof simultaneous fracture of ulna in 56.8%)

THE RÔLE OF CANCELLOUS TISSUE IN HEALING BONE

By T. Wingate Todd, F.R.C.S. (Eng.)
of Cleveland, Ohio
Professor of Anatomy in the Western Reserve University

I. Introduction—Studies on the Skeleton.—Ten years ago I began an intensive study of bone growth and metamorphosis. From time to time I have published more or less fragmentary, apparently dissociated, and preliminary reports dealing with various phases of this study. The inter-relationship of bone and nerves as illustrated by cases of so-called cervical rib in their morphological and clinical relationships, the behavior of bone under pathological conditions and under normal conditions at different ages have been touched upon early in the investigation. It soon appeared, however, that an enormous experience would be necessary if this field were to be properly opened up, and this experience must cover every phase of the subject and leave no line of attack unutilized. During recent years I have therefore refrained from further publication temporarily while necessary collections were being made and data gathered. The war with its abundance of bone cases provided for study, in what one might term the experimental phase, an unlimited material of the greatest value. For it is possible to make observations upon growth processes in long bones of human beings whose interest and coöperation can readily be secured, which are difficult or impossible in laboratory animals.

The present paper, therefore, summarizes the result of an inquiry into the regeneration processes of the cancellous tissue of human long bones as revealed by the cases of chronic osteomyelitis which came under my care in 1918, while I was in charge of surgery at the Base Hospital of Wolseley Barracks, London, Ont. I would first of all express my appreciation of the coöperation and encouragement of my many colleagues, and above all to Major G. C. Hale, officer in charge, and to Major David Smith, my predecessor on the service.

The study of the rôle of cancellous tissue in regeneration of bone is urgent because it has received such scanty notice hitherto as almost to be left out of consideration. Periosteum, cambium layer and compact tissue have all had their share of attention, but cancellous tissue has been largely neglected, and this is probably due to the fact that it does not lend itself to study in laboratory animals so well as the other portions of the bone just mentioned.

The cases to which the present paper has reference were all chronic osteomyelitis resulting from compound, more or less comminuted, fractures of bones of the limbs. The cases were of various duration, and in almost every instance the patient was eagerly longing for freedom after many months of confinement to bed. This attitude of the patient, which was fully

justifiable under the circumstances, demanded ambulatory treatment whenever and as soon as possible. Nevertheless, my predecessor, Major David Smith, had shown that no treatment other than that of permitting the bone cavity, when cleaned out, to heal from the bottom, held out any hope of a satisfactory and permanent cure. The error of permitting the soft tissues to close in, and the unreliability of the bacteriological examination as an indication of when this procedure might be adopted, were already sufficiently obvious.

The practical problems which faced me therefore were, first, the effects of ambulatory treatment of chronic osteomyelitis and the time when the patient's condition would permit of this; second, the methods to be adopted for encouraging and not retarding the rapid and satisfactory healing of the bone cavity; and thirdly, the prognosis for Headquarters regarding the probable duration of the patient's stay in hospital.

It is apparent that the only solution of these problems lies in an adequate knowledge of the rôle of the cancellous tissue.

II. *Methods of Study.*—In each case a careful summary was made of the previous treatment with its results and tracings of all radiograms taken during the treatment were filed with the case records to check up the progress.

After operation, in which the affected area was thoroughly opened up and adequately drained, the operative wounds were kept open by means to be described later, and the abscess cavity permitted to heal from the bottom. From time to time radiograms were taken and in some cases portions removed under local anæsthetic from the healing walls for histological examination in order that the regeneration process and rate might be adequately checked up. By the courtesy of Professor P. S. McKibben pieces after fixation in 10 per cent. formalin were decalcified, cut and stained in the Laboratory of Anatomy of Western University. The methods of staining adopted were the following: Hæmatoxylin and eosin, Toluidin blue and eosin, Mallory, Wright. I shall therefore describe, in the first place, the histological features of a typical healing bone cavity and then proceed to consider the effect of various factors in retarding or accelerating healing.

III. *Typical Healing of a Bone Cavity.*—In the typical healing of a bone cavity the regeneration occurs from the cancellous tissue in the present series of cases. Some authors have termed this portion of the bone the endosteum, a word which, by the obscurity of its precise significance, is misleading and useless. Instances in which the cancellous tissue had been removed and the wall of the cavity was formed, entirely, or practically, by compact bone, will receive later consideration.

Within a few days of the operation the entire cavity is seen to be lined with vascular granulations, which are of earliest and strongest growth where the remaining cancellous tissue is thickest, and especially in that part of the cavity nearest the mid-point of the length of the bone. A portion of the new vascular tissue, removed carefully under a local anæsthetic two weeks after the operation, shows active growth of bone; and again it is

apparent that the earliest and greatest bone growth occurs where the cancellous tissue is most abundant (Fig. 1).

Invading the connective tissue are trabeculæ of recently formed bone, each trabecula having arranged along its surface numerous osteoblasts. The newly ossified bone shows a fibrillar structure, the fibrillæ being arranged in the main in the long axis of the trabecula. Some of these fibrillæ with the accompanying ossein project in among the connective tissue surrounding the bone and more or less enclose osteoblasts on the surface. Near the growing end the newly ossified bone shows as a somewhat flocculent substance obscuring the fibrillæ or entirely obliterating them. In this substance are many lacunar cells, some of which show recent division, either of the nucleus or of the entire cell. In no instance, however, were mitotic figures visible. The term *lacunar cell* is used to indicate a cell which is beyond the osteoblast stage, unsurrounded or only partially surrounded by ossein, but not yet arrived at the stage of the bone-cell, which is apparently completely adult, never again divided, and is surrounded by fibrillar, non-floccular ossein exhibiting canaliculi. Beyond this most recent bone that not so lately formed is of clearer, more evenly translucent character, shows fibrillæ and encloses typical bone-cells each in its lacuna with radiating canaliculi in the surrounding bone.

Occasionally upon the surface of the growing bone can be seen small multinucleated cells, none however exhibiting more than three or four nuclei. The floccular character of the newly-formed ossein and its prolongations into the surrounding connective tissue are shown exceedingly well in preparations stained with Mallory.

Given satisfactory conditions the regeneration progresses steadily until the bone cavity is filled, the rate varying however with the particular bone, the site in the bone, the size of the cavity, and possibly with the age of the patient. This last factor is by no means certain within the usual army limits and is negligible. It is in the later stages of the filling of a large cavity that the growth processes slacken in speed. The march of ossification cannot be adequately followed by means of radiographic examination. In some of the earlier cases, the contraction of the cavity not being discernible radiographically, pieces of the wall were removed for histological examination. This showed that it is only after there is considerable growth of the new bone in density that the radiogram will confirm the satisfactory progress of the case.

It is noteworthy that the cut edges of the compact tissue limiting the bone opening invariably showed little or no tendency to produce new bone, and there was therefore no hindrance from this source in keeping the large superficial opening approximately the same throughout the healing process.

IV. *Effect of Various Factors in Retarding or Accelerating Healing.*—(*a*) *Essential importance of conserving the source of osteoblasts.* That the cancellous tissue is a generous source of osteoblasts has not in the past been sufficiently recognized. Berg and Thalhimer, in a recent paper, however,

make the following striking statement[1]: "The few transplants which included endosteum [*i.e.*, cancellous tissue T. W. T.], though not enough to allow any definite conclusions to be formed, showed an even greater growth from the endosteum than from any other transplants, even including periosteum."

The truth of this statement is abundantly borne out by the cases which form the basis of the present paper. While it is essential thoroughly to open up and expose the entire area of infection, remove all sequestra, and provide effective and ample drainage, the cancellous tissue must be conservatively dealt with and under no circumstances removed entirely. It is the bone abscesses which are "thoroughly" curetted out so that only the compact shell remains which result most disastrously from the point of view of healing. Especially is this the case in those instances in which pure carbolic swabbing is used to finish the destructive work of the curette.

Berg and Thalhimer, following other recent authors (*e.g.*, Mayer and Wehner[2]), emphasize the activity of the osteoblasts lining the Haversian canals in regeneration of bone. Whether these osteoblasts come from Haversian systems in the cancellous tissue or from the lining of the spaces in the tissue is immaterial. Doubtless they come from both places. At any rate, there is no doubt that Haversian systems do occur in cancellous tissue. I drew attention to this in 1912,[3] and recently the fact has been reiterated by Arey.[4]

Regeneration of bone from the compact tissue is slow indeed, and may, for practical purposes, even be non-existent (Fig. 2). A typical case falling within this category is the following:

> Reg. No. 400349.—Pte. A. W. Gunshot wound right tibia.
> *Previous History.*—April 2, 1916: Shrapnel wound right tibia. Shrapnel passed through the limb. April 3, 1916: Operation; scraping and removal of fragments of bone. June 24, 1916: Operation; scraping; apparently allowed to close superficially. February, 1917: Sinus ceased discharging. August 3, 1917: Sinus recommenced discharging. August 4, 1917: Radiographed. August 14, 1917: Operation; thoroughly opened; cavity is three inches long; curetted thoroughly; swabbed out with phenol, alcohol and iodine. December 18, 1917: Cavity reopened and thoroughly scraped. April 6, 1918: Radiographed. April 12, 1918: Cavity reopened; apparently no filling up by osseous tissue scraped and three sequestra removed from lower part.
> *Condition on First Observation.*—May 10, 1918: Radiographed. At this stage the case came under my control. "The area to granulate has steadily increased with each operation. The wound is thoroughly open and draining well. It should be kept open and left alone as regards operative measures from now on."

Further events justified this decision, for on September 25, 1918, when I last saw the case, healing was occurring from the sides and the lower end and the cavity reduced to one-half the size it had been on May 10th. Ex-

amination of the radiograms (Fig. 3) will show how, instead of accelerating healing, the various operations successively created a larger area to granulate. Further, it emphasizes the effect of traumatic and chemical methods in producing the death of bone. There is little doubt in my mind that the late

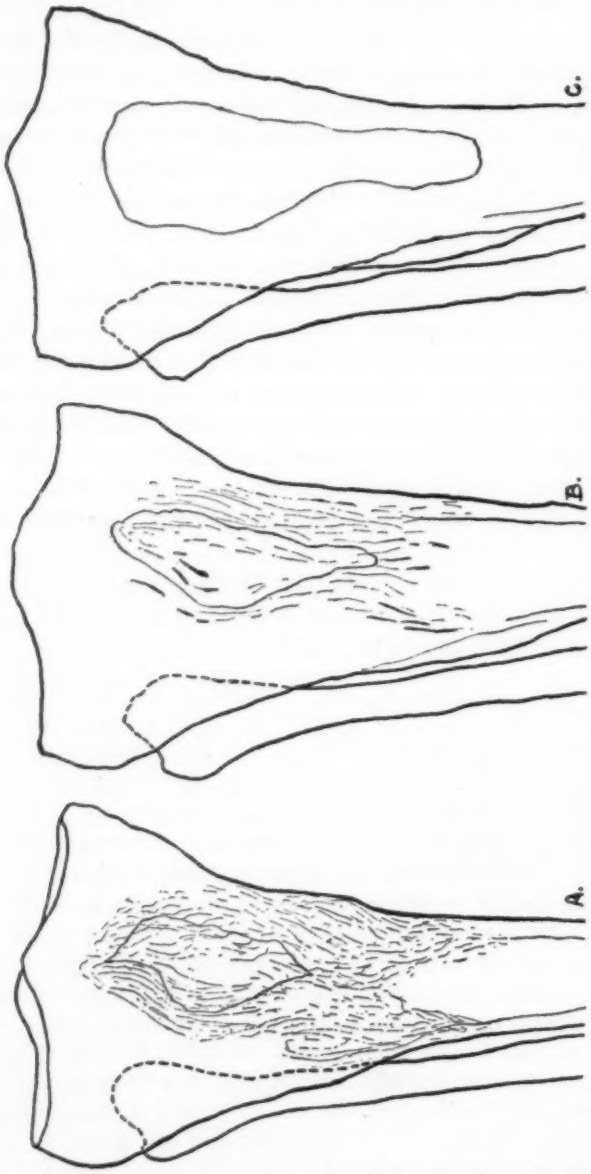

FIG. 3.—Tracings of radiograms from the right tibia of 400349, Pt. A. W., aged about twenty-four years. A, August 4, 1917; B, April 6, 1918; C, May 10, 1918. For details of relation to operations see text. Observe that each successive scraping resulted in a larger field to granulate. The fine line shows the outline of the cavity as produced by operation in the upper part of the tibia. The rough shading represents the "woolly" inflammatory area surrounding the cavity. At the operation on April 12, 1918, efficient drainage was finally established and hence in radiogram C there is no surrounding area of inflammation.

sequestra which were removed on April 12, 1918, were directly due to the vigorous traumatism of the operation of December, 1917. Throughout the healing process it was very evident in this case that little or no regeneration was occurring from those parts of the cavity wall which had been denuded of cancellous tissue.

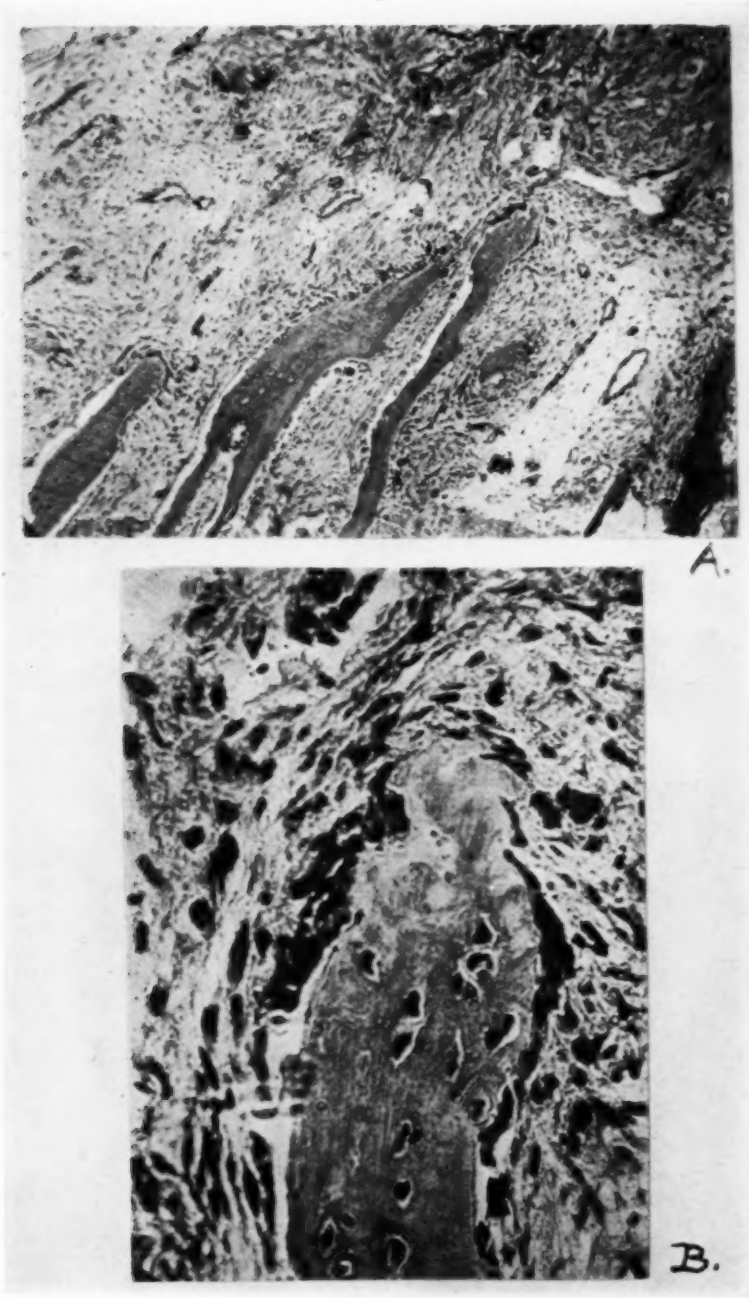

FIG. 1.—Typical regeneration of bone from cancellous tissue of the cavity wall. From No. 400983, Pt. J. R., aged twenty years; gunshot wound left tibia. *A*, Magnification sixty times. Bausch and Lomb Obj. 16 mm.; eye-piece 5.0. Note the bony trabeculæ penetrating the connective tissue of the cavity wall. Hæmatoxylin and eosine. *B*, Magnification 330 times. B and L. Obj. 3 mm.; eye-piece 5.0. Shows the tip of a process of bone from A, projecting into the newly formed connective tissue. For description see text.

FIG. 2.—Left acetabulum of F. S., white, male, aged thirty-eight years (No. 167, W. R. U.): to illustrate the insignificant role played by compact tissue in regeneration. Healed, stellate fracture, apparently but not actually following the lines of fusion of ilium, ischium and pubis. The femur was uninjured. The floor of the acetabulum contains exceedingly little cancellous tissue and the fracture heals largely by fibrous union. Near the acetabular rim there is considerable cancellous tissue and here firm bony union takes place.

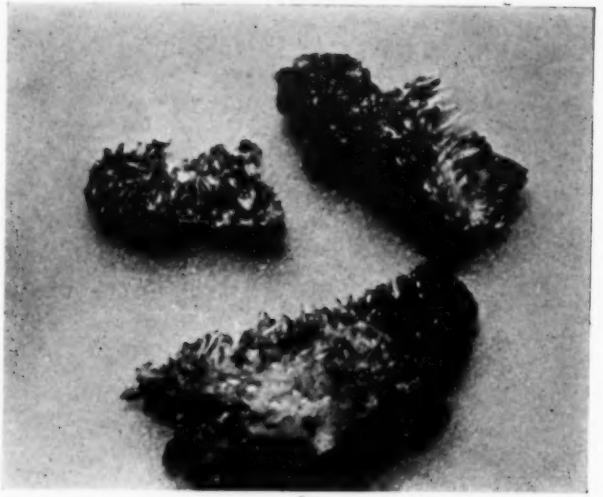

FIG. 4.—Fragments of the cavity wall from No. 226018, Pte. F. E., aged thirty-seven years. Upper left tibia. Twice natural size (No. E. 389, W. R. U.). Note the forest of bony spicules which were imbedded in the pyogenic lining membrane. The upper right-hand piece is shown in profile, the others are shown full-face.

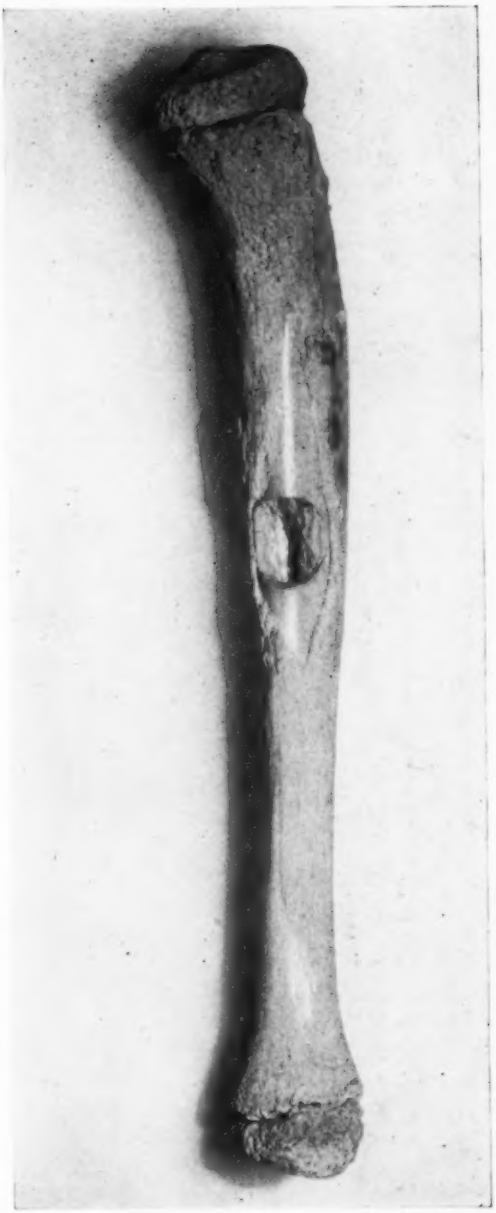

FIG. 5.—Acute osteomyelitis of subperiosteal type. From E. L., male, white, aged nine years, left tibia (No. E. 16, W. R. U.). Note 3 mm. depth of cancellous bone surrounding original incision through the periosteum. This had been deposited under inflammatory conditions in the three weeks elapsing between incision and final amputation. Trephine opening into tibia. The wholly inefficient surgical treatment resulted in infection of the knee-joint and ultimate amputation.

FIG. 6.—Comminuted fracture right femur from J. W., male, white, aged forty-five years (No. 156, W. R. U.). at the stage of commencing callus formation. The callus has been left on the two lower small fragments to show the extent to which it has developed. Callus had formed equally on both sides but not on the edges of these fragments. Such callus as there was has been cleaned off both main fragments and the uppermost small fragment to show the reaction of compact bone to regeneration. Note the generally pitted character of the bone adjacent to the fracture. This is due to the newly developed vascularity of the bone. There is a distinct difference between the upper and lower parts of the fragment which bears the number 156. The upper part shows no pitting: the periosteum was stripped off this and it is dying. The lower part is pitted in consequence of the rarefying action of vascularization. The small amount of callus developed has been removed from this to show the pitted character.

Another case which illustrates the fact that the compact tissue is inadequate to supply osteoblasts is the following, but this time it is the superficial or external face of the compact tissue which comes under observation.

Reg. No. 189528.—Pte. E. R. P., aged twenty years. Gunshot wound left thigh.

Previous History.—May 3, 1917: Shrapnel wound left thigh and leg. Compound fracture upper third of femur. Also small wound middle of calf. Incision: drainage; Thomas' knee-splint; removal of sequestra; repeated drainage. November 13, 1917: Large cavity in femur; further drainage; general thickening of femur to knee. February 2, 1918: Knee immobile with wasting of muscles of leg. April 17, 1918: Fibrosis and atrophy of thigh muscles. Six sinuses on front and inner and outer sides of thigh. Knee is swollen but can be flexed slightly by passive movement. Calf muscles wasted. Movements of ankle normal in range but weak. Movements at hip weak.

Condition on First Observation.—May 19, 1918: Multiple sinuses; periostitis palpable as far as knee, which shows fibrous ankylosis not quite complete. Massage. Patient's general condition poor.

July 8, 1918: Operation. Five-inch incision through outer front of upper thigh. Four-inch counter-incision for drainage outer thigh. One large Y-shaped (4½ inches long) and many small sequestra removed from pulpy granulation tissue within an involucrum of sound bone. Much bleeding as Esmarch could not be properly applied to thigh. As patient's condition would not stand further prolongation of the operation, the three lower sinuses of the thigh were not explored, but left for later treatment, since they did not connect with the present operation area.

August 8, 1918: Second operation. Incision to femur through three lower sinuses. No sinuses found leading into bone, and no dead bone, but multilocular abscesses between the bared compact tissue and the raised and much thickened periosteum. The pus and pulpy granulation tissue were removed and the loculi broken down and thoroughly drained, the wounds as in all cases being kept widely open. During the eight weeks following the second operation, while the patient was under my care, the cavity in the upper femur continued to fill up satisfactorily, but there was no marked growth of bone from the outer surface of the compact tissue of the lower femur forming the base of the superficial abscesses, and there was naturally no bony growth from the thickened and fibrosed raised periosteum. The cambium layer had been completely destroyed and the dense walled cavities between periosteum and bone showed the greatest reluctance to fill up. This lack of bony growth is the more remarkable in this case since the periosteal bony growth everywhere, except in the wall of the abscesses, was extraordinarily vigorous.

In addition to examples like the foregoing, it is well at this stage to stress once more the fact that the cut edges of the wound in compact tissue in cases of chronic osteomyelitis invariably exhibit very slow and unsatisfactory throwing out of new bone.

b. Effect of Pressure on Bone Healing.—Pressure may be applied to healing bone in one of two ways: It may be from without, either as a result of the method of treatment or from encroachment of, and confinement by, the soft tissue. Again, the pressure may be intrinsic as a result of contraction, with scar formation in the granulation tissue of the healing bone which precedes the actual ossification.

Owing to the fact that soft tissues granulate and heal much more quickly than bone, the retention of the wounds properly open becomes a most difficult undertaking. When I came on the service I found that the utilization of glass tubes for this purpose, as adopted by Major Smith, served admirably up to a certain point. At the time of operation the dimensions of the wound in the compact tissue were taken, and a large glass tube, long enough to extend from the surface of the limb into the bone cavity, was moulded to fit the aperture in the compacta. On removal of the packing twenty-four hours after operation, the glass tube was slipped into place and retained there either simply by the dressings or by a narrow strip of adhesive, which was arranged so as not to interfere at all with drainage. The glass tube was also arranged so as not to obstruct the drainage, and if necessary, had holes blown in its sides to this end. In this way the wound in the superficial soft tissues was prevented from contracting and was indeed kept of the same dimensions as the opening in the compact bone. Thus the bone cavity could always be adequately studied throughout its healing, and satisfactorily irrigated and treated in whatever way might seem necessary. The only drawback to the glass tube method was that its base eventually rested upon the healing bone, and this pressure effectually put a stop to progress. It was necessary to devise some method whereby all the advantages of the glass tube method might be retained and its disadvantages overcome. Hence I employed a collar of dental impression wax fitted around the glass tube to prevent it sinking in too far. Dental impression wax, being easily moulded when softened in hot water and readily adhering to a clean glass tube, I was able from time to time to make the adjustment necessary in the length of the tube, so that it always cleared the granulating base of the cavity while penetrating the aperture in the compact tissue. Only when the cavity had satisfactorily healed to the level of the compacta was the tube finally removed and the soft tissues permitted slowly to close in. This closing in was regulated indeed by replacing the old glass tube by new ones of successively smaller calibre. Thus the final stages of healing could be adequately observed and controlled.

The effect of slight pressure in retarding and frequently and eventually in inhibiting bone growth cannot be too strongly emphasized. Ossifying granulations will penetrate into the glass tube if it rests upon the healing base of the cavity, but between these and the ossifying granulations around the tube an annular depression remains where the tube was pitted and prevented the formation of bone regeneration.

If some efficient method be not adopted to keep the wound in the soft

tissues widely open, it contracts within a few hours, and in two or three days has closed so greatly that further examination and effective treatment of the healing cavity are no longer possible. When our patients reached the ambulatory stage their wounds were always examined immediately upon return to the hospital and the tube replaced if by any chance it had become displaced. This procedure was imperative, for if the tube were withdrawn for even a few hours, the dilation necessary to replace it gave great pain, if, indeed, it were possible. Especially must the soft tissues be prevented from falling in for the first six weeks after operation, for even if the operation has been satisfactory, surgically, in every way. the traumatism necessarily incidental to every bone operation will probably cause the death of some part of the cavity wall, either compact or cancellous tissue. As a result, small superficial flakes will be shed as sequestra, and it is frequently these which keep up the long-continued post-operative suppuration and prevent a satisfactory healing. Such small sequestra begin to be shed about three weeks after the operation and the time they take to separate naturally varies with their size. Not until six weeks after operation can one be reasonably sure that flaking has ceased. It is useless to pretend that such sequestrum formation can be prevented by gentle methods. Chisels, hammers. saws and curettes cannot be gently used, for the term gentle must necessarily have reference to the bone tissue which is exceedingly delicate and sensitive to mechanical or chemical interference. This post-operative flaking constitutes a further reason for keeping the wound open and directly contra-indicates the employment of so-called rapid methods of encouraging healing, such as permitting the soft tissues to fall in or closing the wound after or without the use of antiseptics like pure phenol, tincture of iodine or B. I. P. Again the healing cavity must be kept under close observation, for in some cases the granulations which normally are red become fibrous. When this occurs their color changes to gray. Once fibrosis has occurred in the recent granulations, ossification will not penetrate them and healing comes to a stand-still. In such a case nothing will serve but removal of the fibrosed granulations. For this purpose, a further operation under a general anæsthetic is not necessary. It is only needful to remove the fibrosis, and this can readily be done with a curette if the cavity first be anæsthetized with a weak β-eucaine or other local anæsthetic solution to which some adrenalin has been added. The cause of fibrosis in the granulations is often inadequate drainage or cleansing, in which case this must be corrected, but sometimes it occurs apparently from simple indolence of the healing process. Removal of the fibrosis in such cases is usually sufficient to result in restoration of the normal healing process.

c. Effect of Inefficient Drainage upon Healing of Bone Cavities.— The effect of inefficient drainage may be localized to the healing walls of the cavity, but is usually more widely distributed in the bone. A radiogram of such a bone usually shows a varying depth of inflammation around the cavity. This is indicated by a " woolly " appearance of the cancellous tissue

in the plate. In all cases in which this appearance was noted we radiographed the area again about three weeks after operation. By this time the woolly appearance has disappeared if drainage has been effective and the architecture of the bone again becomes apparent and clearly defined.

Local results of ineffective drainage are unhealthy, pale, and exuberant granulations, later becoming fibrosed, and sometimes sequestrum formation. If left uncorrected, these granulations fibrosing, form a veritable pyogenic membrane. Usually, as in the case No. 189528, Pte. E. R. P., previously referred to, masses of such unhealthy granulations fill the cavity and surround and imbed the sequestra when the cavity is opened at operation.

Sometimes cases are met with in which there is a small intermittently discharging sinus leading to a cavity somewhat resembling a Brodie's abscess and lined by a typical pyogenic membrane. Such a case was the following:

> Reg. No. 226018.—Pte. F. E., aged thirty-seven years. Gunshot wound upper leg.
>
> *Previous History.*—December 28, 1916: Shrapnel wound upper left leg. This was a through-and-through wound, the shrapnel passing between the tibia and fibula. The previous records were lost.
>
> *Condition on Admission.*—August 18, 1918: Healed scar popliteal space. Small discharging sinus on front of leg leading into upper tibia, which was very tender locally. Much thickening upper tibia. No paralysis. No loss of sensation. Radiographic examination showed much periostitis upper half of tibia with large area of osteomyelitis occupying upper third or more, and a small perforation in the bone.
>
> August 29, 1918: Vertical incision over subcutaneous surface of tibia. Area of compact bone four and a half inches long by three-quarters of an inch broad around sinus opening removed. The entire cavity was thus laid bare; it was found to be lined by a pyogenic membrane in which were imbedded innumerable tiny osseous spicules from the surrounding compact bone (Fig. 4). Practically the entire cancellous tissue of the upper tibia had been destroyed by the abscess in which were several small sequestra rendered unrecognizable in the radiogram by the opacity caused by the abscess with its surrounding inflammatory zone. The pyogenic membrane was completely removed and careful examination then showed that no further curetting was necessary. In order to provide an adequate exposure of the cavity the insertions of the sartorius and gracilis had to be raised from the bone and the subjacent bursæ opened. The bursæ were left widely open.
>
> September 3, 1918: Healthy red granulations springing from entire cavity wall. The bursæ are also granulating satisfactorily.
>
> September 21: None of the cavity wall is now visible since it is entirely covered by healthy granulations. Tendons of sartorius and gracilis have united afresh to the periosteum at the inner margin of the wound.

At this stage the case passed out of my hands. It will be referred to again later in the paper, but for the moment, apart from the occurrence of a

pyogenic membrane, the case presents two instructive features. First, a minimum of mechanical interference and abstention from the use of chemicals, like pure phenol violently destructive of bone, preserve the small activity of the compact tissue in regeneration. Probably the osteoblasts in this case appeared from the Haversian systems. Secondly, it is not necessary to remove all the compact tissue covering the cavity; enough must be, however, to provide for the fullest possible observation and the most effective drainage. In other words, all procedures in the operation must be as conservative as surgical efficiency permits. As an example of the effect of conservative treatment and very free drainage in encouraging healing, the following case is worthy of record:

Reg. No. 727638.—Pte. C. M., aged twenty years. Gunshot wound thigh.

Previous History.—April 11, 1917: Rifle bullet wound right femur. Compound comminuted fracture middle third. Five operations in France and England. No bone removed so far as could be ascertained. In the early stage of treatment, to obtain reunion of the femoral fragments in good position, extension from calipers on the upper extremity of the tibia had been employed.

Condition on Admission.—June 10, 1918: Discharging sinus front of thigh just above middle. Pocketing of pus in back of thigh. Sequestrum palpable under skin immediately lateral to sinus. Knee contains fluid and is laterally movable: it cannot be hyperextended. Radiograph adds nothing materially to the foregoing.

June 20, 1918: Operation. Six-inch vertical incision front of thigh, excising an old operative scar. The entire middle third of the femur was removed as nine sequestra. In order to do this it was necessary to cut a long and broad channel through the involucrum to which the upper and lower thirds of the femur were firmly united. The sequestra were found imbedded as usual in soft, pulpy, unhealthy granulation tissue which was entirely removed, but no unnecessary curetting done. So far as could be ascertained no sinus tracks were left at the bottom of which sequestra might be lying. It was apparent in this case that sequestrum formation had come to an end. A large opening was made through the involucrum on the lateral and posterior side of the cavity, including the old sinus through which pocketing of pus had occurred and this opening connected with the surface by an equally large incision in the soft tissues. A smaller drainage opening was also made in the lowest lateral part of the cavity wall through to the outer surface of the thigh. The cavity was packed as usual with iodoform gauze.

June 22, 1918: First dressing: Gauze removed under self-administered chloroform by Sollmann's method. Glass tubes with wax collars inserted through anterior and upper lateral wounds. Rubber tube inserted into lower lateral wound.

July 15, 1918: The cavity has discharged profusely, but there have been no set-backs. Rubber tube removed from lower lateral wound which is now permitted to close.

August 15, 1918: Glass tubes have been shortened from time to time. There is now relatively little discharge, the cavity having largely filled up.

September 21, 1918: A very small cavity remains which should heal completely in a few weeks. Discharge very small in amount.

At this time the patient was lost sight of. As this was one of the largest cavities dealt with, it is particularly unfortunate that the treatment could not have been followed to the very end, for the terminal phase and the final results would have proved most valuable.

d. Influence of the Site of the Lesion upon Healing.—One of the most instructive suggestions which this study has brought out is that the rate and facility of healing vary with the site of the cavity in the bone and perhaps also with the particular bone itself. The bones included in this survey are the humerus, femur, and tibia, these being the large pipe bones in which considerable cavity formation is possible. Without much more extended observation it is impossible to assert categorically that the cancellous tissue in one part of the bone has greater regenerating power than in another. In all three bones mentioned cavitation of the middle third is easier to deal with than it is at either extremity, and this is true even of the femur, in the case of which the wound necessarily kept open in the soft tissues is much deeper than in the case of tibia or humerus. That efficient drainage has much to do with the rate of healing is, of course, obvious, but in looking over the records it is noteworthy that in every case where the cavitation lay toward one or other extremity of the shaft it was always that end of the cavity nearest the midlength of the bone which showed regeneration earliest and was the first to fill completely.

Regeneration travelled more slowly as it approached the extremity of the bone, and frequently that end of the cavity nearest the articulation proved almost intractable, so slow was the process of its filling up. Months after the great majority of the cavity was completely healed there would remain a small area near the joint which persistently refused to heal.

As typical of the general rate of healing of a bone cavity in a site where efficient drainage is a simple matter, the following case is instructive.

Reg. No. 400983.—Pte. J. R., aged twenty years, gunshot wound left tibia. October 1, 1916: Shrapnel wound left leg, compound fracture middle left tibia. Three operations in France and England. Discharging sinus: fracture healed.

January 16, 1918: Operation. Opening 1½ inches long made through compact tissue of subcutaneous aspect. Several sequestra, one 1¼ inches in length, removed. Cavity curetted and disinfected.

April 4, 1918: Area again scraped to original size. No sequestra.

June 26, 1918: Glass tube finally removed from wound.

July 23, 1918: Wound healed, skin having dipped slightly into cavity.

Note that the result of the disinfection at the operation of January 16th was to delay greatly the healing so that by April 4th, when a

fresh start was given to the cavity and more effective drainage instituted, very little healing had taken place. Until this date the patient was kept in bed. After this the ambulatory method was adopted, yet twelve weeks after April 4th (*i.e.*, on June 26th), the tube could be removed and sixteen weeks after this operation the patient was discharged healed firmly.

This and other similar cases suggest that there may be more rapid growth of bone from cancellous tissue than from the cambium layer of the periosteum. The cavity which filled in sixteen weeks was about 35 mm. long and 8 mm. deep. In a badly treated case of osteomyelitis of the subperiosteal variety in which amputation was resorted to three weeks after the initial incision, obtained in civil practice from a boy of nine years, not quite 3 mm. depth of cancellous tissue had formed upon the surface of the compacta of the subcutaneous aspect of the tibia (Fig. 5).

e. Effect of Inflammatory Reaction upon Healing.—One case in which surgical erysipelas occurred after curetting a cavity under local anæsthetic suggests that inflammation may have a marked stimulating effect on regeneration.

Reg. No. 405020.—L/C W. D., aged twenty-three years. Gunshot wound left femur.

Previous History.—September 15, 1916: Shrapnel wound left thigh. Compound comminuted fracture femur involving upper third of shaft and both trochanters. Six operations in France, England, and Canada.

March 12, 1918: Operation. Incision 6 inches long outer side thigh. Removal of many small sequestra from region of great trochanter and of one large sequestrum 3¼ by 2 by ½ inches. Until July, 1918, this large cavity very slowly healed, but by then many œdematous granulations had obscured the deeper cavity. These were curetted away under local anæsthetic. Immediately there supervened surgical erysipelas which was treated with antistreptococcic serum and with saturated solution of magnesium sulphate and alcohol locally. After this the area healed much more rapidly and by September 25th only a small cavity was left in the bone, as usual at the end involving the great trochanter.

f. Effect of the Ambulatory Method of Treatment.—As explained earlier in the report there were sufficient reasons for permitting the patient as soon as possible to be out in the open air. Comparing the results with those previously obtained by keeping the patient at rest in bed, this method proved advantageous. There was no retardation of healing, but on the contrary, regeneration occurred much more rapidly than before, probably on account of more effective drainage and improvement in the general health of the patient.

g. Peculiarities of the Lower Tibia.—In several cases where the tibia was involved near the ankle-joint we were tempted to be too conservative, especially when the sinus lay on the back of the bone, owing to a natural

desire to leave undamaged the subcutaneous aspect of the bone. These cases are very difficult to drain, for from the anatomical relations the wound is kept open with difficulty. It was found necessary in every case to open through the subcutaneous surface and make through-and-through drainage, after which no set-backs occurred in healing.

h. The Relation of Compact Tissue to Healing.—It has already been stated that regeneration from compact tissue occurs very slowly or not at all. This was found to be invariably the case and there was never any difficulty experienced through the wound in the compacta filling up before the cavity had become completely filled. This is of course borne out by the usual course of healing of trephine openings in the skull.

The relation of compact tissue to healing of a bone is well shown by the specimen illustrated in Fig. 6. This is from a comminuted fracture of the femur obtained in civil life. Note that the compact tissue in the neighborhood of the healing fracture is filled with small holes, rarefied, in other words, as though the blood-vessels had enlarged. It seems in accord with the views expressed regarding compact tissue by Berg and Thalhimer.[1] In the fragment from which the periosteum was partially stripped off, only the area to which the periosteum was still adherent is rarefied. No change has occurred in the periosteum-free portion.

V. When to Permit the Cavity to Fill Up.—Filling up of the cavity can only be allowed to occur after one is reasonably sure that sequestra resulting from the mechanical damage of operation have separated. Small flake-like sequestra, according to the present experience, take from three to six weeks to separate, those forming from compact tissue naturally taking longer to separate than if they have formed from cancellous bone. Sometimes after the cavity itself had filled and the tube was removed, complete healing was delayed owing to the late separation of sequestra from the edges and surface of the compacta. Once these had been withdrawn healing rapidly took place.

VI. Management of First Dressing and Other Features.—Certain technical features connected with the work upon which the paper is based, though having no relation to the subject matter proper, seem worthy of a simple statement. The first dressing, usually twenty-four hours, but in some of the more extensive cases forty-eight hours after the operation, when the gauze packing is removed, is naturally extremely painful and to men whose nervous systems are already far from normal because of long hospital experience if from nothing else, a source of great mental anxiety in anticipation. I therefore introduced Sollmann's method of chloroform analgesia by self-inhalation[5] and found it entirely satisfactory and without objectionable result in any of the many scores of times it was used.

As regards management of skin and soft tissues there is little to add. The skin was never permitted to creep into a cavity before it had closed solidly to the level of the compact tissue so that the depression in the

skin surface should be quite shallow. As regards periosteum it was found best to remove it entirely to the limits of the opening through the compacta. Any redundant periosteum becomes inflamed, acutely tender, and is much in the way of the necessary glass tube. In those early cases in which redundant periosteum was left by way of experiment, it had always to be removed later under local anæsthetic.

SUMMARY

1. Cancellous tissue is one of the chief agents in regeneration of bone, and like the cambium layer of periosteum, should be treated at operation in the most conservative manner, consistent with thorough exploration and drainage.

2. In regeneration the cancellous tissue nearest the mid-length of the bone grows most rapidly, whereas that in or near the articular extremities shows less readiness to proliferate and fill the cavity.

3. Septic bone cavities should be permitted to heal from the bottom, the wound in the soft tissues being kept widely open until this has occurred. The least possible mechanical disturbance of the cancellous tissue should be employed and no "disinfection" of the cavity attempted, for this simply kills the remaining tissue from which regeneration is expected.

4. Regenerating bone is very sensitive to and easily affected by pressure, even of soft tissues, and by inefficient drainage. It is not adversely affected by the ambulatory method of treatment.

5. Compact bone plays a very minor part in regeneration.

REFERENCES

[1] Berg, A. A., and Thalhimer, W.: Regeneration of Bone. ANNALS OF SURGERY, 1918, vol. lxvii, pp. 331–347.

[2] Mayer, L., and Wehner, E.: An Experimental Study of Osteogenesis. Amer. Journ. Orthop. Surg., 1914, vol. xii, pp. 213–244.

[3] Todd, T. W.: A Preliminary Note on the Development and Growth of Bone. Journ. Anat. and Physiol., 1912, vol. xlvii, pp. 177–188.

[4] Arey, L. B.: On the Presence of Haversian Systems in Membrane Bone. Anat. Rec., 1919, vol. xvii, pp. 59–61.

[5] Sollmann, T.: Chloroform Analgesia by Self-Inhalation. Journ. Amer. Med. Assoc., 1918, vol. lxxi, pp. 657–8.

THE RECOGNITION OF DEAD BONE BASED ON PATHOLOGICAL AND X-RAY STUDIES *

By Dallas B. Phemister, M.D.
of Chicago, Ill.

When bone dies rapidly and in appreciable quantity from infection in osteomyelitis, compound fractures, tuberculosis and rarely in lues, it is at first indistinguishable either by gross or röntgenologic appearance from the adjacent living portions. Only after the occurrence of further changes in the living and the dead bone can its extent be determined. A detailed knowledge of these changes is essential for arriving at a diagnosis, especially by means of the X-rays, and for planning suitable and properly timed operations.

The changes in the dead bone are of great importance in establishing its identity. There are changes in color which are of assistance at operation. Dead compact bone turns white from the loss of circulation and of soft parts, but usually it requires some time for their absorption and the difference in appearance early between it and the pinkish living bone is insufficient to make it a reliable guide for removing the dead bone before the line of separation has begun to form. Necrotic spongy bone is frequently dark brown or red, due to the presence of old blood and necrotic marrow in the cancellous spaces where it is sheltered from attack. Granulations may grow into and be removed with a spongy sequestrum, giving it a reddish color which is sometimes difficult to distinguish from living spongy bone. By holding the sequestrum under the tap, blood and granulations are readily washed out, leaving the white cancellous bone.

Granulation tissue soon attacks the dead bone, but its activity becomes most marked after the acute inflammatory stage subsides. The tasks for the granulations are to separate the dead bone from the living, to reduce its volume or break it up by absorption and to extrude it from the field through the discharging sinuses.

Separation of dead from living bone is accomplished more rapidly than the other changes. The granulations attack both living and dead cortex along the line of junction, from both periosteal and endosteal sides, forming two irregular tortuous grooves which are gradually deepened until they meet. This results in the formation of a jagged irregular zone of demarcation two to five mm. in width, depending on the thickness of the sequestrum. These grooves are frequently seen at early operation, or in the X-ray picture as a nick or uneven dotted line in the cortex, before separation is complete. In the separation of dead

* Read before the American Surgical Association, May 5, 1920.

spongy bone, because of its loose structure, a zone of granulation tissue forms simultaneously along the entire line of junction which results in early sequestration. The time required for separation is extremely variable according to the density and thickness of the bone involved. It ranges all the way from five or six days with very thin cortex or spongiosa of the small bones to five or six months with the thickest portions of the shaft of an adult tibia or femur.

Reduction in volume of the dead portion occurs from lacunar absorbtion by the granulations along its surfaces. There is no diffuse internal loss of lime salts from dead bone, so that any remaining portions retain

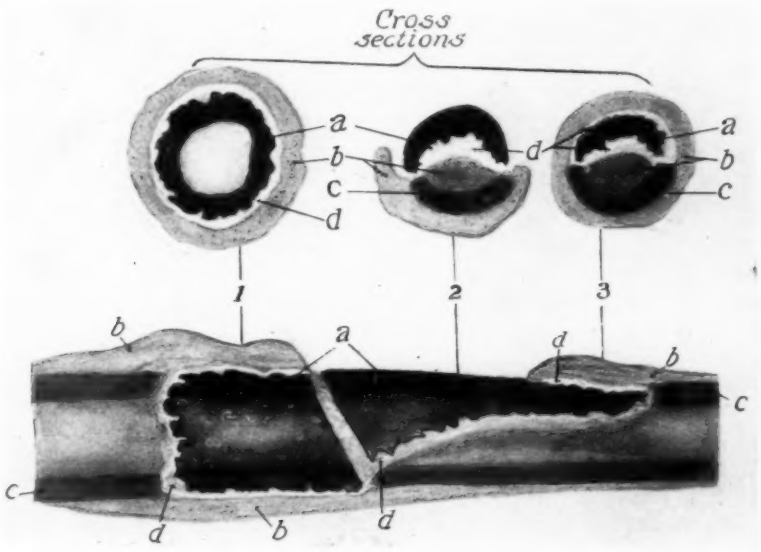

FIG. 1.—Sketch of X-ray of old infected fracture showing atrophy of surviving cortex, involucrum formation and two sequestra with well-preserved fracture lines and external surfaces that are eroded where adjacent to and little or uneroded where remote from living bone; *a*, dead bone; *b*, new bone; *c*, atrophied old bone; *d*, zone of demarcation. Cross sections show sequestra with erosion along 1, external surface; 2, internal surface; and 3, both internal and external surfaces. Differences in density well shown.

their original density. The rate of surface destruction varies greatly in different portions and is dependent largely upon the relation of the surfaces to surrounding living bone and to the channels of purulent discharge. Where living bone is in close contact with dead portions granulations springing from and supported by it attack the dead bone, producing an uneven worm-eaten surface in a comparatively short time. But those surfaces that lie at a considerable distance from living bone may show little or no signs of erosion even after long periods of time. Granulations arising from a soft part's covering attack dead bone slowly, and where they spring from the walls of a bone cavity will not bridge a wide gap and vigorously attack a relatively small enclosed sequestrum. Thus the periosteal surface of dead cortex will become extensively eroded in

those portions surrounded by involucrum, but will remain smooth or little eroded where involucrum fails to form. Similarly the condition of the endosteal surface will vary with the degree of involvement of the shaft at any level. If less than half of its circumference dies, endosteal

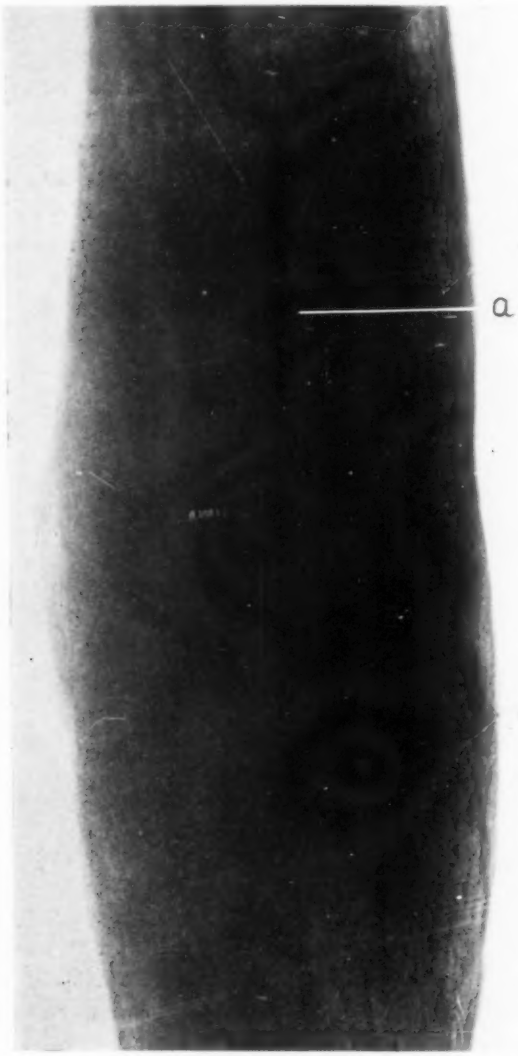

FIG. 2.—Almost stationary sequestrum in osteomyelitis of seven years' standing. *a*, Broad space between sequestrum and involucrum.

new bone will form from the surviving portion and maintain granulations in contact with the dead bone, destroying it from the endosteal surface. But if more than half the circumference is destroyed there will be frequently little or no erosion of the deeper portion of the endosteal sur-

face. When the entire circumference is dead, the endosteal surface will remain unchanged for months or even years, except at the ends of the dead tube where granulations will invade the canal for a short distance. Where an involucrum is present destruction from the periosteal side may

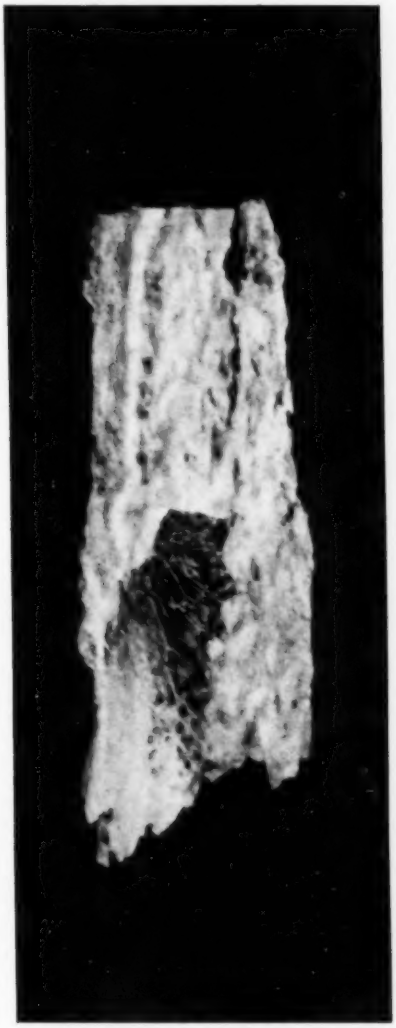

FIG. 3.—Photograph of part of sequestrum from Fig. 2. Periosteal surface markedly eroded, but endosteal surface undisturbed, as shown by presence of cancellous bone seen through window.

finally lead to perforations of the dead cortex, after which endosteal erosion from invading granulations may occur. These features are illustrated in Fig. 1, which is a composite sketch of the X-ray picture in the later stage of infected compound fracture showing different conditions of

surfaces in sequestra according to their relation to living bone. Fig. 2 shows an X-ray and Fig. 3 is a photograph of a seven-year-old sequestrum of the entire circumference of the shaft of the femur resulting from osteomyelitis at the age of ten. While markedly eroded externally, it shows through a window endosteal surface and spongy bone that had not been touched by granulations.

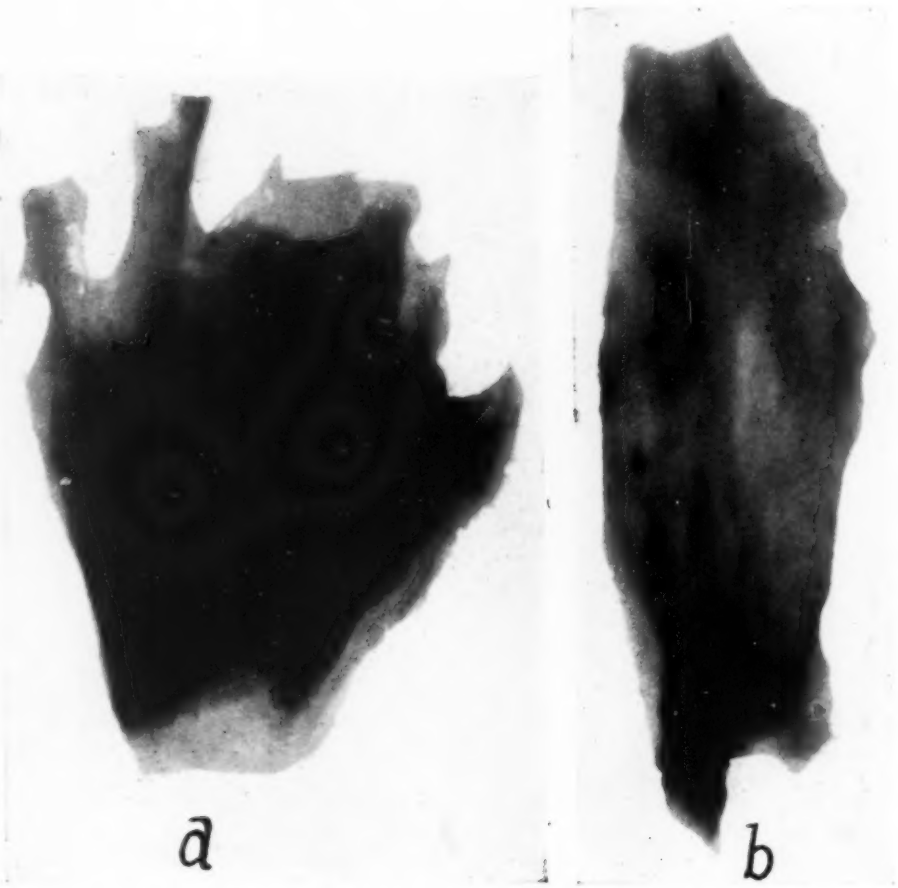

FIG. 4.—Cortical sequestra from gunshot fracture six months old. *a*, possesses original density because uneroded along periosteal or endosteal surface; *b*, eroded by granulations and density unevenly reduced.

There is little destruction of necrotic bone that occupies or borders on discharging channels, as the discharging pus in which it is bathed keeps the surrounding granulation tissue unhealthy. This is frequently seen in infected fractures where the fracture surfaces of the dead ends remain sharp and uneroded for months partly because of the restraining action of pus escaping from the deeper portions (Figs. 1 and 12-4).

Because of this unequal action of granulations upon its surface there may be marked variations in outline of different portions of a sequestrum.

Where unattacked the surface will be unchanged and the volume and density of the sequestrum will be what it was at the time death occurred (Figs. 4 *a* and 12–3). But where extensively eroded with deep pockets and sharp, irregular projections, the density will be unevenly reduced (Figs. 4 *b* and 5 *b*). Any portion that remains will have its original internal structure. These are all points of the greatest value in the X-ray diagnosis of dead bone.

The rate of destruction is greater while the dead piece is still at-

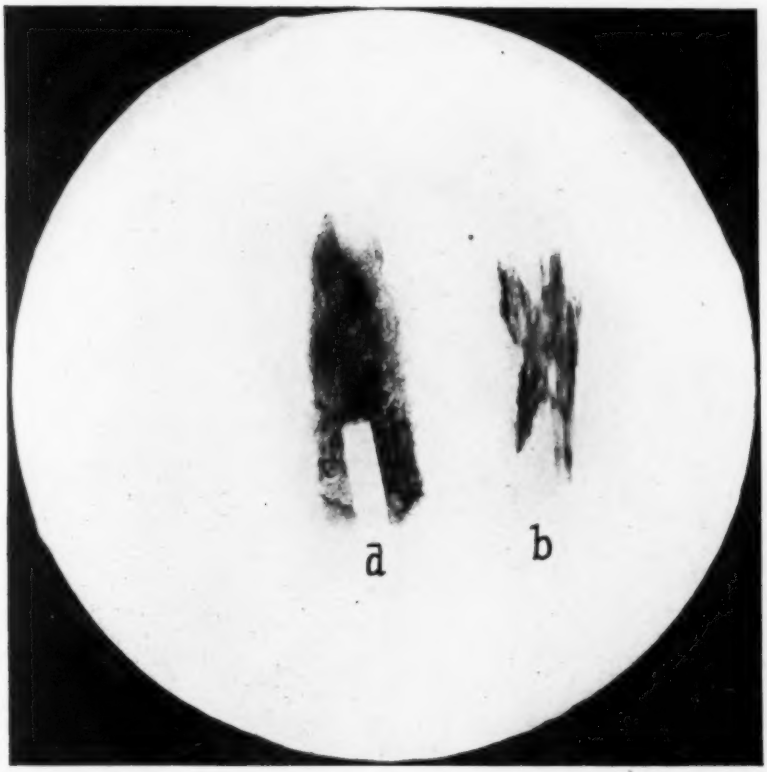

FIG. 5.—X-rays of *a*, involucrum from Fig. 13, No. 5, showing even, spongy character. *b*, sequestrum eroded, showing reduced uneven density but compact character.

tached to or incarcerated by living bone. Once it is loosened and the sequestrum moves into a freer position, especially if into a large bone pocket, destruction proceeds at a much slower rate. Splinters killed at the onset in infected fractures may be found little eroded at operation months afterward. In case of death of the entire circumference with complete encirclement of involucrum, the periosteal surface of the shaft is rapidly attacked at first, and where cortex is thin, especially in young children, it may be eaten through and fragmented, after which the pieces may be destroyed or extruded through the sinuses. But where cortex is thick, continued concentric erosion gradually leads to the development of

a wide space between sequestrum and involucrum as the latter becomes dense and does not fill in about the dwindling dead piece. This retards the action of the granulations, and such loosely enclosed sequestra may then stand for years with only slight reduction in size. This is illustrated by Fig. 2, showing a practically stationary sequestrum with a wide space between it and sclerotic involucrum.

Destruction of dead cancellous bone occurs more readily than of cor-

FIG. 6.—Scattered destruction in osteomyelitis of spongy portion of bone; an indirect sign of the presence of sequestra.

tex which usually gives rise to the first changes shown in the X-ray. In acute osteomyelitis of the end of the shaft the entire cancellous portion may become necrotic, but that is not the rule. Usually the dead bone is irregularly distributed and granulations developing from the adjacent surviving portions produce signs of scattered destruction. Fig. 6 shows such a condition in an eight-year-old child with osteomyelitis of the upper end of the femoral shaft of five weeks' standing and a pathological fracture of the neck. More sequestra than could be identified in the X-ray

FIG. 7.—Gunshot wound of hip four months old with sequestrum (*a*) in head casting an evener and heavier shadow than atrophied surrounding bone. Articular surface on sequestrum preserved.

were found at operation throughout the region presenting signs of destruction. Smaller areas are usually completely broken down and it is rare to see large sequestra persist in this location. But in infected com-

minuted fractures of the ends of the bones, especially from gunshot wounds, large sequestra may form and persist with little more destruction than comes from formation of a wide zone of demarcation. When bordering on the joint cartilage in the presence of a complicating arthritis, the sequestrum stands out prominently because of the preservation of its original density and of the rim of bone supporting the articular cartilage, which on account of its inaccessibility to granulations, is not destroyed;

FIG. 8.—Section of sequestrum shown in Fig. 7. Interior trabeculæ intact and articular surface unbroken except in one place.

whereas that over the remaining living cartilaginous surface is irregularly broken down (Figs. 7 and 8).

A cone-shaped area of necrosis of considerable size is not infrequent in tuberculosis of the metaphysis or epiphysis and is usually broken down, leaving a cavity. When bordering on the articular surface of the joint, such a sequestrum is more apt to persist and maintain its original density. Occasionally calcification will occur in its cancellous spaces and thereby further increase its density so that it may cast a heavier shadow than the corresponding normal area on the other side.

FIG. 9.—X-ray of excised wall of tunnel (*a*), sequestra and shell fragment in gunshot fracture of femur six and one-half months old. Atrophied cortex of most of wall is longitudinally streaked by dilated canals: sequestra compact.

Changes in the Living Bone.—Changes in the living bone consist in local absorption and regional atrophy and transformation of preëxisting bone, and in new bone formation.

Local absorption of living bone bordering immediately on the dead

was observed by John Hunter to be of greater importance in the process of sequestration than absorption of the dead bone itself.

Regional atrophy results from disuse and is dependent on the degree and duration of loss of function. A limited osteomyelitis producing partial loss of function for a comparatively short time, may produce little atrophy. Extensive osteomyelitis causing marked and prolonged loss of function, produces much atrophy. Infected fractures, because of prolonged and complete loss of function produced by the fracture, infection, and immobilization, frequently show, after five or six months, the highest degree of atrophy. In the case of cortex, it occurs by diffuse absorption of lime salts, mainly along the course of the haversian canals, and is slightly more marked on the endosteal than on the periosteal side. This produces an even loss in density which, when marked, may be striated longitudinally by the lines of dilated canals (Fig. 9). In cancellous bone there is reduction in numbers and size of trabeculæ in a way that frequently gives a spotted appearance in the X-ray. Atrophy of the living bone usually occurs faster than destruction of the dead bone, hence after a length of time varying with the size of the bone, the dead portion casts a heavier shadow in the X-ray than the living (Figs. 1 and 12). This relation obtains until there is resumption of function and increase in density of the atrophied portion, or until there is further destruction of the dead bone. Then the two portions may be of equal density, but in the living bone it will be evenly and in the dead bone unevenly distributed.

In case of cancellous sequestra bordering on joints this process may be reversed, as the texture of the dead bone is even, while the surrounding living bone shows areas of spotted atrophy and absorption from osteomyelitis. This is illustrated in Fig. 7, of a gunshot wound of the right hip of four months' standing with sequestrum formation in the head of the femur. Fig. 8 is of a section showing the even texture of the sequestrum.

Transformation of preëxisting bone is of less importance in the recognition of dead bone. In osteomyelitis with sequestrum and involucrum formation, the old cortex at the limits of the sequestrum may develop a greater degree of porosity than does the remaining living bone from the atrophy alone. It also gradually shifts to align itself with the involucrum, leaving the dead cortex in its original position. This shifting occurs fairly early, especially in the thin bones of children, but so late, where thick cortex of large bone is concerned, that it is of little diagnostic value. Transformation occurs late in infected fractures healed in malposition, but other signs make it possible to recognize the dead bone much earlier.

New Bone Formation.—New bone formation occurs along the course of the dead bone from the periosteum, unless there is also death of its osteogenetic elements, which is frequently extensive in infected fractures, but limited in osteomyelitis. It also occurs from the endosteum of the affected level unless the entire circumference has been killed. It extends back on the

FIG. 10.—Secondary sequestrum (*a*) from wall of tunnel (*b*) in gunshot fracture of femur seven months old. Sequestrum resulted from denudation at operation five weeks before it and tunnel wall were recovered. Both have same density.

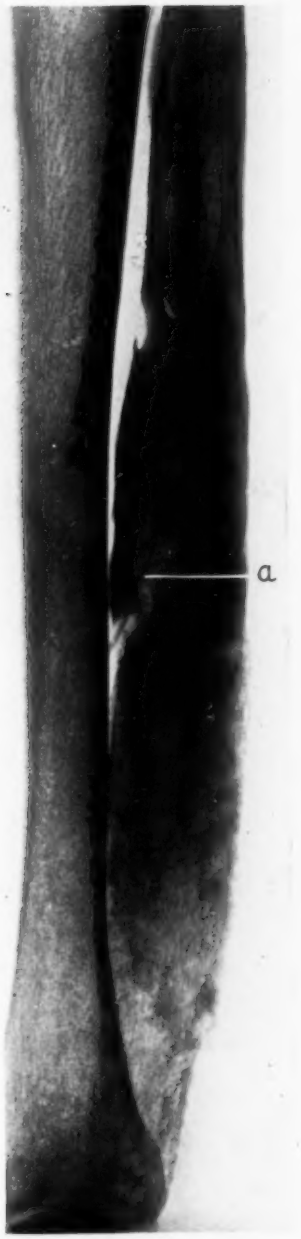

FIG. 11.—Old hypertrophic osteomyelitis of fibula, cancellous except about sequestrum. Acute recurrent osteomyelitis three and one-half weeks old in lower half producing extensive irregular absorption. At operation extensive irregular areas of necrosis and absorption found.

living shaft at the limits of the dead bone and gradually tapers off at a distance, depending on the cause of the infection. The newly formed bone is spongy early, but gradually increases in density (Fig. 5 *a*). With the resumption of function it slowly assumes a lamellated character. But if there is protracted disuse, as in ununited gunshot fractures, it may in turn undergo atrophy, vacuolation, and absorption.

There is a definite line of demarcation between the newly formed bone and dead bone, but none between it and old living bone. However, peripheral callus on the ends of living cortex may be laminated with an inner spongy and an outer compact layer, which occasionally may simulate involucrum and dead space about a sequestrum. Careful inspection of good X-ray plates will show the presence of a spongy shadow forming a narrower inner layer than is represented by the dead space about a sequestrum.

Irregular osteophytes and islands of new bone develop, especially as a result of gunshot fracture and secondary to operation with displacement of osteogenetic elements. The islands are frequently hard to distinguish from displaced sequestra, but, as a rule, have a more even density with dull fading margins, and their spongy nature can be made out in the X-ray. Displaced sequestra are usually derived from cortex and have a compact texture with sharp irregular outlines.

Secondary Bone Necrosis.—Secondary necrosis is not uncommon from a flare-up in the course of chronic osteomyelitis or from the spread of infection following operation in which extensive fresh-cut or denuded bony surfaces have been created. It differs from primary necrosis in that it usually occurs in atrophied old bone, spongy new bone, or a combination of the two. As a rule, large sequestra do not form since the infection is limited. Also further atrophy does not ordinarily occur in the surrounding living bone as is the case after primary bone necrosis. Consequently, the shadow cast by the new sequestrum is not heavier than that of the surrounding living bone and may be even fainter, as increase in density of the latter can occur from resumption of function during the time required for sequestration. Very small secondary sequestra frequently form from the cut or denuded surfaces produced at operation in chronic osteomyelitis or infected fractures. Because of their reduced density it may be difficult to distinguish them from islands of new bone formed from stripped-off osteogenetic elements or from small chips. The zone of separation forms faster in secondary than in primary bone necrosis because of the more porous character of the necrotic portion. Fig. 10 shows a secondary sequestrum *a*, which separated four weeks following operation, from one wall *b* of a tunnel, in a seven-months-old gunshot fracture of the femur. The wall was removed two weeks later and the sequestrum, placed alongside its defect, casts the same density as the portion from which it was separated.

Shaft that has first hypertrophied from old osteomyelitis and then become

porous from years of quiescence of the infection may become reinvolved from lighting up of a neighboring focus. In this case the infection will spread in the spongy hypertrophied portion and produce irregular areas of necrosis similar to that in cancellous bone of the ends of the shaft and epiphysis. The X-ray appearance is quite similar in the two conditions. This is well illustrated in Fig. 11. There had been an old osteomyelitis of the lower four-fifths of the fibula beginning nineteen years before, at the age of twelve. It discharged intermittently from the middle and lower portions for four years at which time dead bone was removed at operation and the lower portion healed. But a discharging sinus leading to the middle portion persisted. There had not been an acute exacerbation of the infection and no interference with function until three and one-half weeks before, when an acute osteomyelitis developed in the lower half leading to extensive abscess and fistula formation. X-ray shows a markedly enlarged lower four-fifths of the fibula with three distinct types of change. The upper one-fourth is enlarged and fairly evenly porous with a smooth surface. The second fourth is hypertrophied and contains an irregular canal with dense walls casting a heavy shadow in which lies a sequestrum, *a*, the lower end of which protrudes through a cloaca. The old fistula leads down to this. The surface in this region is also smooth. The lower half is enlarged and spongy, but throughout there are numerous small irregular areas of reduced density and marked irregularity of the surface, indicative of bone destruction. The entire hypertrophied portion except the external malleolus was excised subperiosteally, and the lower one-half found to be the seat of diffuse acute osteomyelitis with irregularly distributed areas of necrotic bone and bone absorption. The upper one-fourth was cancellous, but free from acute disease. No doubt the lower one-half possessed a similar but more marked cancellous structure, which permitted the acute infection, starting from the neighboring chronic focus, to spread throughout its entire extent.

Diagnostic Points in Septic Necrosis.—To sum up, the points by which we distinguish between dead and living bone are density, demarcation, and contour. These are best determined from a practical standpoint by means of the X-rays, and, after advent of the period when they may be of assistance in the management of the condition, can be expressed as follows:

The density of dead bone is greater than that of an equal volume of surrounding living bone. It retains its original compact texture. Living old bone has its density evenly reduced by atrophy and is occasionally streaked from dilated longitudinal cannular markings. Newly formed bone is of low density and spongy in texture. These are well illustrated in Fig. 12, showing a gunshot fracture of the femur seven months old. Differences in density are striking. Eight sequestra were removed. Fig. 13 is a photograph of the four large ones that could easily be identified in the X-ray and of a piece of involucrum (5) that encased sequestrum No. 2, the surface of which is markedly eroded, while that of Nos. 1 and 3,

which were not covered by involucrum, are smooth. No. 4, presenting a flat surface, was identified by its sharp fracture lines.

There are numerous variations from these general statements. Dead

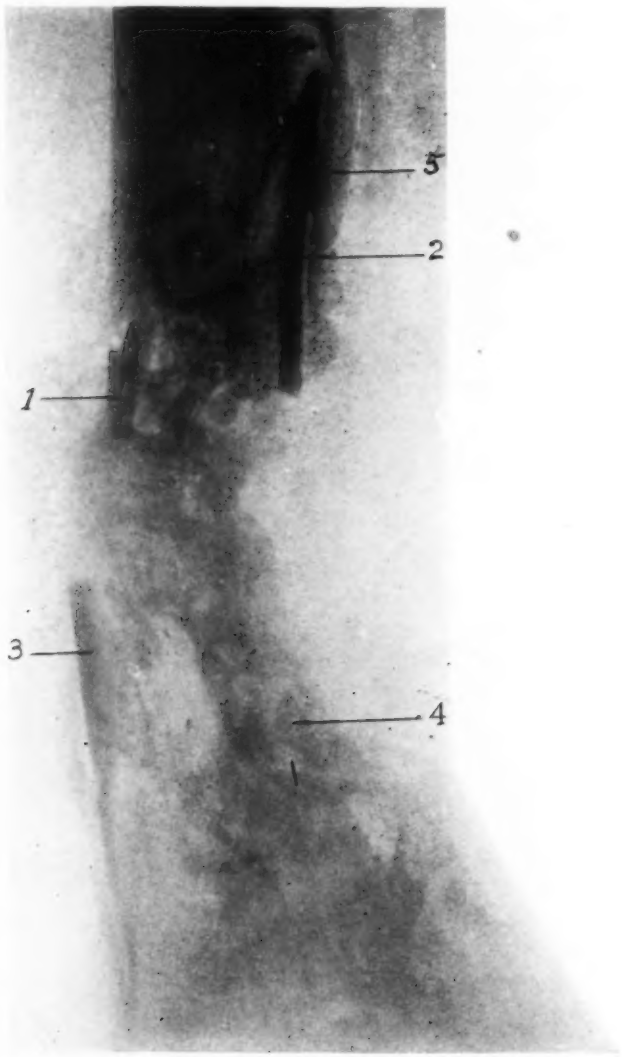

FIG. 12.—Gunshot racture of l. femur seven and one-half months old, showing extreme variations in density of dead bone, new bone and old living bone. Dense uneroded sequestra, 1 and 3, uncovered by involucrum; eroded sequestrum. 2, covered by involucrum; 5, thin sequestrum; 4, seen on flat and identified by its fracture line. Photograph in Fig. 13.

bone when extensively eroded has its shadow density reduced, which may be equal to or below that of the living bone, but is distinguished from the latter by its blotchy uneven character. Secondary sequestra usually show no variation in density from the adjacent living bone. The

line of demarcation between dead and living portions is usually sufficiently wide and clean cut to be of great value in diagnosis, but any oblique or tortuous portions, especially when overlapped by heavy living bone, may be indistinguishable or very imperfectly made out. Notches

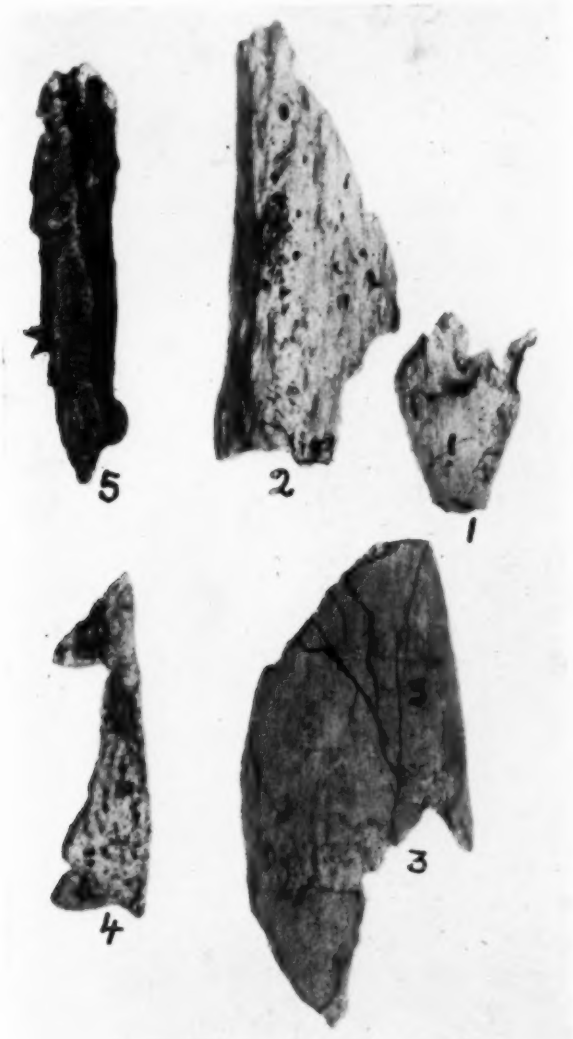

FIG. 13.–Sequestra from case shown in Fig. 12. Numbers same, but pieces reversed.

or unevenly streaked or dotted lines may indicate incomplete separation of the dead piece.

The outline of the sequestrum is of great diagnostic value. Its surface is smooth, sharp, and straight where unattacked, but irregular and jagged where erosion has occurred. Sharp spicules, especially about the

ends, are frequently to be made out. Preservation of the smooth curved cortical rim in sequestra bordering on an articular surface and of clean-cut fracture lines late in infected fractures are points of value. The compact texture of dead bone gives its outlines a sharpness that the less

FIG. 14.—Two small sequestra at 1. Wound healed for three months.

FIG. 15.—View at a right angle to Fig. 14. Sequestra in fork of upper fragment.

dense and frequently growing living surfaces do not possess. Evidence of irregular destruction of spongy bone at the ends of the shaft in osteomyelitis is indirectly a pretty safe sign that dead portions are present even though their outlines cannot be determined.

There are many difficulties in distinguishing dead bone in the X-ray,

the greatest of which results from overlapping of shadows of necrotic and living portions which obscures the details of each. This can usually be obviated by obtaining views from different angles. Thus a line of de-

FIG. 16.—Transplant of ulna ten weeks old in adult dog. Casts heavier shadow than atrophied cortex above and below.

FIG. 17.—Tibial transplant *a–b* three months old in non-union of humerus. Lower 2 cm. (*a*) infected and separated as sequestrum casts a heavier shadow than the rest of the transplant which took and has been transformed.

marcation, a sharp point, or worm-eaten surface, may show plainly at one angle and faintly or not at all at another, and a flat piece of sequestrum seen from the side may show a low density and be unrecognizable, but seen on edge is easily recognized by its greater density. Thick overly-

ing soft parts frequently obscure the finer details of internal structure of different types of bone.

The presence of dead bone can nearly always be diagnosed, but frequently the exact number of pieces can not be determined, especially when they are small. It is a not uncommon experience to find, at operation in osteomyelitis and infected fractures, twice as many sequestra as were suspected from the X-rays.

Fistulæ usually persist as long as dead bone is present, because bacteria invade its canals and cancellous spaces, rendering sterilization impossible and keeping up a discharge. In marked contrast, projectiles in gunshot wounds usually heal in after subsidence of the acute infection, as their interior contains no bacteria and surface sterilization takes place. In old gunshot fractures it is common to see several pieces each of dead bone *with* sinuses at the seat of fracture, and missile fragments *without* sinuses in the adjacent soft parts. Wounds containing small sequestra may heal and remain closed indefinitely, but eventual lighting up of the infection usually occurs. Ununited fractures and defects requiring bone transplantation should be scrutinized, especially for the presence of tiny healed-in sequestra, and if such be found they should be removed and the transplantation postponed until the wound has been sufficiently long healed.

Fig. 14 shows the X-ray of an ununited gunshot fracture of the humerus healed for three months. The two small, sharp, dense spots (1) in the shadow of upper fragment suggested dead bone, consequently, a view at right angles was obtained (Fig. 15). It shows two small shadows in the fork of the upper fragment which at operation were found to be produced by two wheat-grain sized sequestra that were surrounded by moist granulations.

Density of Transplants.—The difference in density between dead and living bone in septic necrosis suggested the possibility of a similar occurrence in aseptic necrosis, such as takes place in uninfected bone transplants. Histological studies have shown that nearly all of the transplanted compact bone undergoes aseptic necrosis which, after reëstablishment of the circulation, is gradually replaced, through a process of creeping substitution, by new bone formed from the surviving unossified osteogenetic elements of the transplant in case the latter takes, or growing in from the surrounding bone where it does not take.

Atrophy would be expected to occur more rapidly in the adjacent living bone than in the transplant, because time would be required for the reëstablishment of circulation and the beginning of absorption in it with replacement of the dead cortex by new and less dense bone. Experiments on dogs, details of which will be published later, show this to be the case. A section of ulnar shaft two-thirds to one and one-half inches long, excised and reimplanted, is denser and casts a heavier shadow from the fourth to the tenth week than the adjacent atrophied fragments. This is well shown in

Fig. 16 of a ten-weeks' experiment. After this time the density of the transplant gradually approaches that of the fragments.

That a difference in density gradually develops between the infected and uninfected portions of a human transplant is illustrated by the following case: A tibial inlay graft was inserted for ununited gunshot fracture of the lower end of the humerus. Mild infection occurred with fistula formation at the seat of the fracture. Fig. 17 shows the X-ray at the end of three months. Two centimetres of the lower end of the graft underwent septic necrosis and separated as a sequestrum. It casts a heavier shadow than the rest of the graft which took and has undergone considerable transformation.

ON THE DIAGNOSIS AND THERAPY OF BONE TYPHOID

By G. Bohmansson, M.D.

of Orebro, Sweden

first assistant surgeon at the orebro hospital

In the March number, 1919, of the Annals of Surgery I have published a case of multiple typhoidal bone-foci in an eighteen-year-old girl, where the diagnosis could not be made until after the chiselling up and cultivation of bacteria from one of the closed bone-foci, where Widal's reaction was negative in the blood and the pathological-anatomical examination did not give any fixed points for an etiological diagnosis, and where finally the patient had not previously gone through any fever-sickness which could have been interpreted as typhoid.

In the case in question an experiment was even made with autogenous vaccine therapy, which turned out well and encouraged me to continue in the same direction. I therefore beg to give a short account of yet another similar case which seems to me to support in every respect the conclusions which I had drawn from the first case.

Case II.—The patient, a woman, aged fifty-three years, sickened in August, 1918, with headache, pains in stomach and back, accompanied by diarrhœa, which continued for two weeks. No cough and no catarrhal symptoms from the upper bronchial tubes. Afterwards lay another five weeks languid and weak and with pains all over her body. Was taken into the internal department of the hospital here, October 13, 1918. The *status* was then: The spleen palpable, somewhat enlarged. On the apex of the right lung a good deal of rustling. Heart without remark. The abdomen considerably distended. Temperature, 39°–40° C. Pulse 100–110.

On the ensuing few days a slight further enlargement of the spleen was observed. Blood. Red blood-corpuscles, 3,200,000; white blood-corpuscles, 3900. Ficker for paratyphoid negative. The patient afterwards lay in an almost unchanged condition with a febris continua which subsided lytically in the middle of November, but afterwards lay subfebrile with nearly 38° C.

On December 27, 1918, a slightly painful swelling over the fourth right rib. Sound of friction in the neighborhood of auscultation. The white blood-corpuscles now 6900. The following day the patient was moved over to the surgical department.

Under the right breast, corresponding to the fourth or fifth rib, was a non-fluctuating, slightly painful swelling as big as a plum, adhering fast to the bone.

On December 27th operation (Lange). Resectio costæ, ribs III

and IV. Scraping out of granulations. On an incision being made a granuloma was discovered, partly infiltrating in the pectoralis major. The seat of granulation may be traced under the costal cartilage into the pleura, from which latter it seems to have emanated. Iodoform tamponade. Microscopical examination: Granulation tissue (Westberg).

On February 1, 1919, I saw the patient for the first time. The fistula after the operation is still discharging. On the right tibia shaft and in centre of same a lightly-rounded, slightly-painful swelling. Temperature still subfebrile. Röntgen shows on the corresponding place a thin periosteal layer. Wassermann negative. Widal negative for typhoid and paratyphoid.

The anamnesis with the prolonged high fever, enlargement of spleen and leucopænia seemed to me to favor the belief of its being typhoid, in spite of the negative result of Widal. Further localization of the multiple bone-foci; rib and tibia diaphysis, as tuberculosis with the last-mentioned localization were exceedingly unusual. I therefore decided to make a bacteriological examination from the tibia focus as being the only sure method of obtaining an etiological diagnosis. The focus was laid bare and the limited hyperplastic periostitis cut away (writer). Under the periosteum a shallow concavity in the corticalis. The histological examination now answered to tuberculosis (Professor Westberg).

The sterilized preparation was sent in for the purpose of bacilliculture to the bacteriological laboratory of the public institute of medicine (Professor Pettersson). It was here found that stavelike bacilli in cultivation were growing from the same which were agglutinated by typhoid serum in strong dilution, less strong by paratyphoid A and B. Vaccine was subsequently prepared from the cultivation received in the same way as in the case previously referred to.

On February 23, 1919, a vaccine therapy was introduced with doses increasing from 5,000,000 up to 5,000,000,000 in subcutaneous injections every other day. Moderate rise in temperature and slightly increased pain in the bone-foci on the days ensuing the first injections. After four injections afebrile. *Widal positive typhoid,* afterwards quick healing. The patient remained for control of the result until March 24, 1920, and was then discharged as cured. Subsequent examination on April 12, 1920: Perfectly healthy. Widal negative.

What appears to me to be of special interest even in this case is the state of reaction in accordance with the Widal method before and during vaccine therapy. In conformity with a previously expressed opinion, I consider that this argues in favor of a low virulence of the bacteria and would further emphasize the already well-known fact that the intensity of the primary disease does not appear to be of any importance with regard to an eventual appearance of pyæmic bone typhoid.

SURGICAL ASPECTS OF THE CHARCOT JOINT AND OTHER SYPHILITIC BONE AND JOINT LESIONS*

By Frederic J. Cotton, M.D.
of Boston, Mass.

Because of disasters, everyone is afraid of the Charcot joint. Because of poor results no one is interested—clinically. I suspect we have done very badly by them.

This paper can be only the expression of a lately awakened interest on my part, and can cover only the clinical aspects of a small group of cases in which treatment seems to have helped. Already colleagues have volunteered notes of isolated like cases, and perhaps a few months of further painstaking may teach what I think we have not known—the whole "natural history" of these joints: The clinical picture; in whom they occur and why; how they progress; what speeds or stays this progress; why certain cases reach a limit of damage while others go from bad to worse; how far general or local antisyphilitic treatment or treatment of the cord lesion can help; whether they are, or can be made, reasonably safe for operative interference, etc.

We have all seen Charcot joints that had reached a certain stage of tolerance or quiescence: it was a couple of cases that showed, under salvarsan (given on general principles), a real reparative process that aroused my interest. An astonishing proportion of the Charcot joints, as we all know, occur in cases of tabes so early as not to have been diagnosed or even suspected—so early that motor function is intact—the working problem is only that of the joint, and of the preservation of its function.

Case I.—A man, seen in 1915, who had "dislocated" a hip in bowling, while in supposedly perfect health. The hip had been "reduced;" the X-ray showed a supposed fracture, really a plaque of *new* bone. Examination showed some limitation of motion, no pain; also no knee-jerks, and a suggestion of the Argyll-Robertson pupillary reaction.

Careful questioning elicited the story of a half-forgotten infection, of twenty years before—a history of severe "neuralgia" in the legs, two years before, and in some measure to date—at irregular intervals, resistant to treatment given by his physician. There was not a trace of ataxia discoverable. Patient lean but healthy, exceptionally vigorous and active.

Rest in bed, fixation in abduction for three weeks, then a leather pelvic spica belt, steadying the trochanter, and crutches. A course of 606 treatments by Dr. Otto Hermann.

* Read before the American Surgical Association, May 5, 1920.

Very enterprising, he discarded crutches for a cane earlier than I wished, and after about four months even the belt went into the discard. The process was followed with X-rays (many of them unavailable now, with other plates of the late Dr. Walter Dodd) and destruction went on apace for a number of weeks, then after completion of the 606 course, it checked, and the joint, now obviously subluxated, grew firmer.

To-day he is as active as ever, does an unusual amount of walking, is known as a very successful and progressive man in his business, and considers himself well, though he has a limp and carries a cane, though more from habit than from apparent necessity.

CASE II.—A widow, aged fifty-two years, was sent to me for results of a fracture of eight weeks' duration.

The skiagraph showed an obvious Charcot joint, and I was able to get from her doctor the first X-ray taken at the time of the fracture. There was a fracture of the radial styloid, but even then obvious preceding pathological changes were evident in the plate. There was no history, then or since, of any kind of infection, but reflexes and pupils confirmed the story, and the Wassermann reaction was positive. She, too, had a course of salvarsan treatment by Doctor Hermann.

Then I tackled the wrist—useless, swollen, shapeless and grating—opened it, cleaned out the loose original fragment, detached plaques of new bone, loose capsular tissue, etc., closed it, and got first intention, and presently, with the aid of a steel reinforced leather brace, a return of fair function in the hand. She then developed a mental condition which the neurologist, Dr. J. W. Courtney, called general paralysis; this yielded only slowly to the after course of mercurials.

Now, after three years, on reëxamination, she is mentally normal or thereabouts, conducting her business—a lodging house—without obvious non-success, and the wrist, weak, of course, from lack of the removed section of the radial base, is at worst no worse, is without reaction of any sort, and the hand is useful.

CASE III.—A fireman of forty years, was seen by me while I was still in military service. He had a Charcot joint of the left ankle, a sufficient history of infection of many (20 plus or minus) years ago, with some treatment and no later signs of trouble noticed until the ankle began to give a bit of trouble after a slight wrench. Out of practice at the time, I referred him to the City Hospital, where Doctor Nichols did a thigh amputation, precipitated by sepsis at or about the ankle. I understand that the amputated specimen showed an extraordinary degree of syphilitic endarteritis throughout.

What is of interest in this case is the great toe of the *other* foot, which "went bad" shortly after the amputation.

The X-rays shown give the before and after of a treatment with salvarsan and a reasonable protection of this joint by proper, heavy-soled shoeing (in a policeman's boot).

This patient is, or was at last report, an active citizen of these

United States now sojourning in Canada, with one artificial leg and one police shoe, and I think the X-rays confirm the fact of real repair in this once sad-looking joint.

CASE IV.—Next comes the case of a man of forty, supposedly in good health, who began to have trouble—pain and some weakness, in his knee after some unusually heavy lifting. This grew worse and he went to one of the hospitals where a diagnosis was made on the basis of the X-ray of an early hypertrophic arthritis. The X-ray is here shown and corresponds pretty closely with that of the other knee taken at the same time. I have examined the plates. He grew less able to use the knee, though in no great pain, and when I saw him, about two months later the condition clinically was obvious—a thickened knee with some fluid, nearly painless, with marked abnormal lateral mobility, no muscle spasm. The patellar reflexes were gone, the pupils characteristic. There was not and is not now any ataxia. Nearly twenty years ago there was an infection about which he remembers little. There was no systemic treatment.

In the unfortunate shuffle of hospital responsibilities he dropped into other hands, was told the case was hopeless, and no treatment recommended. About three weeks later I saw him with his own doctor in consultation, told him of my more recent views that I am trying to express here, and had him fitted to an apparatus of the convalescent Thomas knee-splint type with a slide lock at the knee and with special plates and pads to correct the bow-leg deformity which had increased in the three weeks to a marked extent. Otherwise there was no essential change in his condition. He was then put through the usual 606 treatment. The Wassermann reaction was positive.

The knee was kept quiet for a time, but after a month put into active moderate use—with the support of the apparatus which was modified at intervals to keep pace with the correction of the bow-leg deformity. Now the leg is practically straight—the abnormal lateral motion decreased from about 25 degrees to less than 10 degrees and he gets about comfortably and pretty solidly. At present he is looking for a job. His general condition is excellent. The X-rays in this case show, what is suspected we are going to find regularly in these cases properly treated, a stage of disintegration before repair starts. In the last plates there is certainly an increase in density of bone, and no destruction since the last plate of a month previous. This joint will never be cured, of course. Whether it will ever be good enough to go without apparatus I do not know as yet. But at least the destruction has been checked and a derelict has been transformed into a reasonably useful citizen.

CASE V.—The next case is a tabetic, not an early case, a real advanced tabetic, diagnosed a dozen years ago, known to me for four years or more, but never a patient of mine until this winter when I was called in to treat the results of one of his many falls. He had fallen five weeks before, striking his right shoulder from behind, injuring his left thumb at the same time.

The thumb showed thickening and subluxation of the first phalanx forward on the metacarpal with abnormal mobility and loss of power. The shoulder was a loose joint subluxating forward to the coracoid and back to its socket. There was much swelling—fluid—in front. Pain was little, but loss of ability to help himself about very distressing to him as his legs and hips are not very useful, and there is a good deal of ataxia of the arms. The X-ray taken at this time showed almost nothing in the shoulder and only the subluxation in the thumb.

Fixation in this case was very difficult, but with a shoulder cap and adhesive something was done with the shoulder and the luxation of the thumb was reduced and held by firm adhesive strapping. The collection of fluid in front of the shoulder persisted. It was tapped twice and permanently reduced. The first tap produced about ℥ii of serous fluid. Examination showed sterile culture and no spirochætæ to be found by dark field illumination. He was turned over to Doctor Hermann and put through a course of salvarsan treatment.

To-day his thumb is still strapped and shows thickening, but the mobility is less, the usefulness greatly better. The shoulder still shows abnormal mobility and thickening and a collection of fluid and the subluxation has become permanent, but at much less than its maximum range. Consequently there is some loss of forward motion of the arm, but the usefulness of the joint is much increased. He still wears a shoulder cap held down by straps.

Case VI.—In this man there was a practically spontaneous fracture of the thigh a year before I saw him. He was treated in the City Hospital; X-rays taken at that time show, first, no pathology in the plate taken directly after the fracture; secondly, union, prompt and with enormous callus as one sees at times in tabetics. This was a tabetic fracture not the result of gumma. A year later he came to my service in January with a spontaneous fracture of the other hip, intracapsular without impaction. I was suspicious and found an early tabes present, never suspected before. Also I found a definite *severe* Charcot joint in the great toe-joint of the other foot, which had been opened up in another hospital six months before and had promptly healed without essential improvement.

The usual systemic treatment with protection of the hip, first in plaster, later in a Taylor splint, has at least slowed up any progress. The fracture ends show only a little erosion—increased density of bone is beginning to be evident. The characteristic shadows of bone plaques about the capsule have become obvious, and clinically the abnormal mobility is less; he is not yet bearing weight on the leg.

The tabetic process in this case was so little advanced that the neurologist hung in doubt for a time before confirming my diagnosis.

Case VII.—Seen in February in consultation with Dr. McIver Woody, was sent to him with regard to the results of a Pott's fracture sustained last July. The lateral deformity was extreme, the mechanical defect disabling through clumsiness and fatigue, though there was no pain. A rather too short antisyphilitic treatment cut

short by his business followed the diagnosis and the confirmation of a positive Wassermann test; an outside upright and strap reduced the deformity a little, relieved strain, and gave fixation. He is now in Canada active in business and with at least great relief from his disability.

CASE VIII.—Shown by this X-ray is of a transition class. This man, an Italian of fifty years of age, otherwise vigorous, sustained an ankle injury over a year ago. He came to the hospital for disability, without much pain in walking. The picture is suggestive particularly in relation to the extent of the process without pain. Aside from this he shows only a local thickening of periosteal bone in one humerus. Wassermann positive, weakly. Tabes doubtful, but J. J. Thomas, the neurologist, finally decided for very early tabes, and the patient is under anti-specific treatment and presently to have brace support. The absence of history is of little use, he being no speaker of English and not very alert mentally aside from that.

This seems to me a borderline case—syphilitic beyond a doubt—and to be classed as a Charcot joint clinically, but showing much likeness to the non-tabetic specific bone lesions, particularly in the massive overgrowth of the bone ends themselves.

I have lately been following two cases interesting from this angle.

CASE IX.—A boy of ten years of age, three years under treatment for congenital specific changes in the tibia, hyperplastic and ulcerative, now cured as to the destructive process and the symptoms, but with no retrogression in the overgrowth of bone.

CASE X.—A knee in a woman twenty-four years of age, syphilitic, but not tabetic. The knee lesion, of a year's duration before I saw her, variously treated in that time under mistaken diagnoses, gave trouble because of weakness and of muscle atrophy with pain present, but in no proportion to the destructive lesion present. There was thickening, grating, and considerable free fluid. After treatment for the syphilis and proper fixation for the knee the case is clinically cured. But the X-rays before and after show no change save for return of normal bone density about the local erosion on the joint surface and the last was taken after considerable use of the joint without recurrence of trouble. Further than this the case can hardly be distinguished from the early stages of the other knee shown, Case III, clinically or by the X-ray.

In these two cases as in the ankle just shown, we have retrogression of symptoms, retrogression of the process in the soft parts, but no definite retrogression of bone overgrowth. The same is true of the thigh in Case VI, the colossal callus of the tabetic fracture of a year ago remains unchanged.

This is true of all these few joint cases and perhaps the general similarity of the X-ray picture has misled us in these cases as it has misled some into thinking syphilitic bone changes in the shaft unaffected by treatment. In both instances may we not say that proper treatment first

sets a limit to the bone changes; that under proper treatment bone repair does occur and that symptoms, save those from mechanical damage already done, are done away with?

There is nothing new about this you will say, and there is not. We have all seen the remarkable tolerance of some horrid looking Charcot joints under prolonged use; some cases have been helped with supports, and many have been given routine treatment as syphilitics. All that is new is the point of view, I think.

We have thought of Charcot joints as one loss not recoverable in the losing game of the patient with locomotor ataxia. Please think of the lesion as I have come to think of it, as a joint disease that occurs in syphilitics, not always or even usually crippled by ataxia, a lesion not completely curable, but not without power of repair or destined to inevitable progress, but capable under proper handling of restoration to safe use.

Probably such cord changes as exist are permanent—whether antisyphilitic treatment will safely check such changes where they are is doubtful. But as to the joints, let us handle them as syphilitic joints. They may be dependent on cord changes; they are certainly aggravated, as they are said to be caused by the trauma of use of an insensitive joint, but that they are traumatic has no support in any other traumatic process. Personally, apart from any spirochætæ in the joint which others have found, though I did not, I cannot believe the condition other than syphilitic.

Properly handled, they certainly show a checking of the destructive process even if this is not prompt, and certainly a regenerative capacity in the bone, a tightening and shrinking of the capsular tissues, and absorption of waste fluid and soft tissues are uniformly evident. Two cases in this series besides the one I operated had been cut into without disaster or notable slow repair of soft parts.

The many operative disasters I know of in these cases all antedate proper syphilitic treatment, and it is not unlikely that many cases may by proper treatment be brought within the safe operative field for ankylosing operations. At all events, here is a class of joint lesions mainly in cases of a tabes so early as to have given no other symptoms, hitherto almost uniformly "given up" and neglected, in which it appears that useful work can easily be done, with some prospect of better developments to come.

FORWARD DISLOCATION OF THE ASTRAGALUS AND WITH IT THE FOOT*

By Robert Henry Fales Dinegar, M.D.
of New York, N. Y.

Stimson in his work on fractures and dislocations divides the possible tibiotarsal dislocations into five groups, namely: Forward, backward, inward, outward, and upward. Of these there are but relatively few collected cases, of the backward variety about 26; forward, 10; inward, 26; outward, 27; and upward but 4.[1] No doubt at the present time other cases have been added, but it is fair to assume that the relative proportion of these must all be the same.

If we leave out of consideration the very rare upward dislocation, of which Stimson found but two records (though some have seen four cases[2]), there remain but the four commoner varieties. From the figures given above we see that, of these the forward dislocation of the astragalus and with it the foot, is by far the rarest. It is a case of this variety that I wish to report.

Case Report.—A young adult male, aged twenty-two years, an iron worker by trade, was carried into the Emergency Department of the hospital, from a building upon which he had been working, twenty minutes after the accident had happened. The following was the history given by the patient. While engaged in working on the construction of a building, the patient's position was such that his right leg and foot were advanced about 2½ feet in front of the left extremity. The patient's weight was borne on the forward (right) leg, while his left extremity was used to balance with. This leg was tense from the contraction of the muscles, and was extended at the knee, the foot dorsi-flexed at the ankle. The right leg was slightly flexed at the knee and the foot was at right angles with the line of the tibia.

While in this position the patient was suddenly hit on the left heel by a rapidly moving iron beam of great weight. This naturally exerted considerable force. The astragalus, and with it the foot, was dislocated forward; at the same time the patient lost his balance and fell to the side, inverting his left foot. The mechanism of dislocating the foot forward is in part the causative factor in fracturing the tips of the malleoli and displacing the internal fragment forward (by avulsion through the ligaments). But more especially the inversion and lateral displacement of the astragalus is the chief factor and, it would appear, the means of displacing the fragment of the tibia laterally outward.

* From the Surgical Service of Dr. Charles N. Dowd, at the Roosevelt Hospital, New York City.

FIG. 1.—Before reduction.

FIG. 2.—Before reduction.

FIG. 3.—After reduction.

FIG. 4.—After reduction.

The man was a relatively normal white male; the left foot was swollen about each malleolus and across the dorsum. The skin here is very tense. An abnormal bony prominence is easily palpable in the upper dorsum of the foot. The foot appears lengthened, feels cold, is cyanosed, and the discoloration reaches the tips of the toes. The heel appears to be shortened and it is impossible to grasp the os calcis in the usual manner. The normal sulcus on each side of the tendo achillis is obliterated. Motion is impossible. There is tenderness over both malleoli with crepitus at the external. The foot appears to be more plantar-flexed than the opposite, and the hollow of the instep is increased. The malleoli appear to be nearer the sole and heel than normal. The patient is unable to bear any weight on the foot.

From the physical signs and symptoms a dislocation of the astragalus was apparent. The X-ray being immediately at hand, skiagraphs were taken before reduction was attempted (Figs. 1 and 2). In these pictures the following points are noted: Before reduction, Fig. 1: (*a*) The astragalus is dislocated forward. (*b*) The posterior portion of the os calcis is further forward and nearer the malleoli than normal. (*c*) The foot is more plantar-flexed than normal. (*d*) The hollow of the instep is increased. (*e*) Malleoli are nearer the sole of the foot than normal. (*f*) The tip of the internal malleolus is fractured and is displaced forward. (*g*) The tip of the external malleolus is fractured but not displaced. (*h*) The relation of the astragalus to os calcis and navicular is normal. Fig. 2: (*a*) Tarsus slightly inverted. (*b*) Astragalus displaced laterally outward and inverted. (*c*) Fractured tip of the internal malleolus is displaced inward. (*d*) Fractured tip of the external malleolus is in good position.

While the pictures were being developed the dislocation was reduced. The method consisted in traction on the os calcis and dorsum of the foot, while with the fingers of the hand, making traction on the dorsum, the astragalus was pushed downward and backward. The surgeon was assisted by counter-traction at the knee. The patient was in the recumbent position. The astragalus slipped into place easily, with the usual feeling of crunching snow. Almost at once the cyanosis began to clear and the foot to feel warmer. Great relief from pain was experienced. The reduction required no anæsthetic. The foot tended to keep the normal position when at rest.

X-ray plates were again taken and when seen the position was as is indicated in "after reduction," Figs. 3 and 4. The corrections of the points enumerated above are noted.

A padded plaster case extending from just below the knee to the base of the toes was applied. The foot was put at right angles with the line of the tibia. The patient experienced such relief from the reduction and the support of the case that he was able to leave the hospital on crutches. The next day he was seen in the Out-Patients' Department; his foot felt very comfortable in its plaster encasement, and very little pain was experienced at the site of the

trauma. The patient reported at frequent intervals and the case was removed on the twenty-first day. No deformity and only a moderate amount of stiffness and limitation of motion was noted. These soon disappeared under active and passive motion, baking, and massage. When the patient last reported, six weeks from the date of the accident, he had an excellent result and practically perfect function.

Discussion.—There are two classical modes of producing this dislocation, according to Stimson,[3] namely: (1) When the foot is in dorsiflexion and pressure is exerted through the long axis of the tibia downward and backward; (2) when direct pressure is made forward on the foot, at the same time the leg is pushed backward while making an angle of 90°. In the case reported above I believe the mode of production to be slightly different from either of the two accepted methods. The position is quite characteristic of the first, except that pressure was not made down through the long axis of the tibia (as even the body weight was on the opposite leg), but by a force pushing the foot forward. In this respect it resembles the second method, only the angle between the foot and leg was considerably less than 90°, about 55° in fact, and no pressure was made backward on the tibia.

This manner of dislocation, when the upper fragment is not fixed, except by muscle spasticity, could only be accomplished under certain conditions. First, although the leg and dorsum of the foot made an angle of 55°, the muscles were so taut that they, while not exerting pressure, rendered the leg so stiff as to splint it. Secondly, the object exerting the force on the foot was one of great weight. Thirdly, that this object moved quite rapidly. (Just as a sufficiently quick flick of the finger will displace a card from beneath a penny on the finger without carrying away the penny.) All these I believe to be potent factors, because if the blow was of less force and slower, it would have tended to push the extremity out from under the individual rather than to quickly dislocate the foot forward.

REFERENCES

[1] Stimson, L. A.: A Practical Treatise on Fractures and Dislocations, 6th ed., pp. 837–842.
[2] Wendel: Beitrage zur klin. Chir., vol. xxi, p. 123 *et seq.*
[3] Stimson, L. A.: A Practical Treatise on Fractures and Dislocations, 6th ed., pp. 837–842.

ADVENTITIOUS LIGAMENTS SIMULATING CERVICAL RIBS*

By Arthur Ayer Law, M.D.
of Minneapolis, Minn.

Thorough study, by many observers, of the clinical entity known as cervical ribs, has crystallized into a definite symptom complex, the reaction which follows when the eighth cervical and first dorsal nerves of the brachial plexus are lifted up, stretched taut and angulated over an adventitious rib, and, in addition, are pinched in the angle formed by the scalenus anticus muscle and the first rib and there subjected to the constant hammering trauma from respiratory movements during the excursion of the lungs.

With the pressure neuralgia of the brachial plexus cords, there is a coincident angulation and pinching of the subclavian artery as it arches over the extra rib and is crowded forward into the angle formed by the muscle and the rib; this insult occasionally results in the symmetrical dilatation of the artery distal to the rib which simulated a fusiform aneurism and which has been so thoroughly studied by Keen and Halstead.

That only about 10 per cent. of the cervical ribs give local and peripheral symptoms is conceded. When these local and peripheral symptoms do occur, they are manifested in the root of the neck and in the forearm and hand, and are an expression of nerve irritation, with motor and sensory changes, with loss of trophic control and with ischæmia of the extremities from vasomotor changes; these symptoms are now thoroughly well established and recognized.

Minor points of discussion as to the physiological mechanics which produce these symptoms in cervical ribs still give zest to study, notably Todd's and Kieth's assertion that the circulatory changes in the forearm and hand are the result of pressure upon sympathetic fibres in the lower cords of the brachial plexus—these fibres from the rami communicantes entering the plexus with the eighth cervical and first dorsal nerves. They affirm that pressure of the cervical ribs upon the lower cord of the plexus causes irritation or even obstruction of these sympathetic fibres which produces trophic changes in the intima and media of the arteries, followed by secondary proliferation and hypertrophy of these coats which results in a coincident pallor and coldness of the hand and upon occasion in gangrene of the finger tips. Other observers assert that the anæmia of the extremity results from a mechanical obstruction and angulation of the subclavian artery in the neck at the site of the offending rib. The British have reported this same symptom complex following pressure from a high first rib.

In 1914 and 1915, while clinically studying a series of cervical ribs, the

* Read before the American Surgical Association May 5, 1920.

writer noted what he finds other observers have reported, that in the cases of some of the shorter and more rudimentary ribs, the forward projecting tips of these ribs were occasionally attached by a definite ligament to the first rib or to the sternum.

When, then, a case presented itself for relief from symptoms which were typically those of cervical ribs, yet in which the radiographic evidence revealed no hypertrophy or elongation of the transverse process of the seventh cervical vertebra, we remembered the ligaments attached to the rudimentary ribs and venturing to explore the neck found a definite adventitious ligament arising from a normal seventh cervical transverse process and being inserted into the first rib at the scalene tubercle with the scalenus anticus muscle. This ligament was about four millimetres wide and two in thickness, it looked like any ligament and had definite longitudinal fibrous bands; it was as taut as a bowstring and tightly stretched over it and sharply angulated were the two lower cords of the brachial plexus and the subclavian artery. Mobilizing the phrenic nerve and pulling it aside, the scalenus anticus muscle was sectioned and then the adventitious ligament; when the ligament was cut, the marked tension upon the nerves and artery was immediately relaxed.

Since the first case noted in 1916 we have operated upon three others, differing only in minor details from the first one, while each of them gave typical cervical rib symptoms, yet in no instance were cervical ribs present. Radiographic study, although it showed no adventitious ribs, did show what seemed to be a tendency on the affected side to a pulling down of the last cervical transverse process closer to the transverse process of the first dorsal vertebra than was shown on the normal side. Three cases showed no hypertrophy of the transverse processes of the last cervical vertebra, while the fourth was of the " cow-horn " type with the process slightly longer than on the other side.

There was in all four of the cases the invariable angling over the ligament and the pinching of the nerves and artery between the ligament and the scalenus anticus muscle, just as these structures are pinched between the muscle and rib in the cervical rib cases. The ligaments were all tightly stretched, and while they all had their origin from the tip of the seventh cervical transverse process, they varied markedly in their point of insertion, for one was inserted with the scalenus anticus muscle into the scalene tubercle of the first rib, another into the costo-clavicular ligament, the next into the sterno-clavicular ligament, while the last was inserted well towards the mid-line into the interclavicular ligament close to the head of the clavicle. In none of the cases studied was there a tendency to dilatation of the subclavian arteries distal to the ligament, and only in one was the pulse appreciably weaker on the obstructed side. Röntgen rays in one of the cases showed a marked osteoporosis of the phalanges of the ring and little fingers of the affected side; this was undoubtedly trophic in origin.

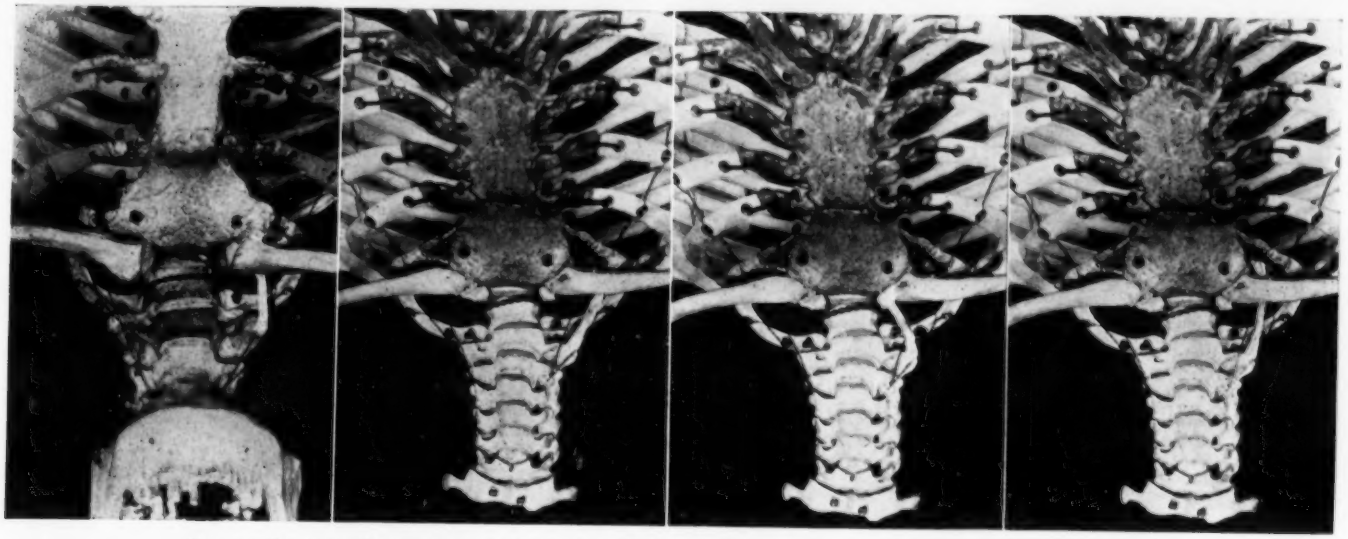

FIG. 1.—Demonstrating constant point of origin of adventitious ligaments and the different points of insertion.

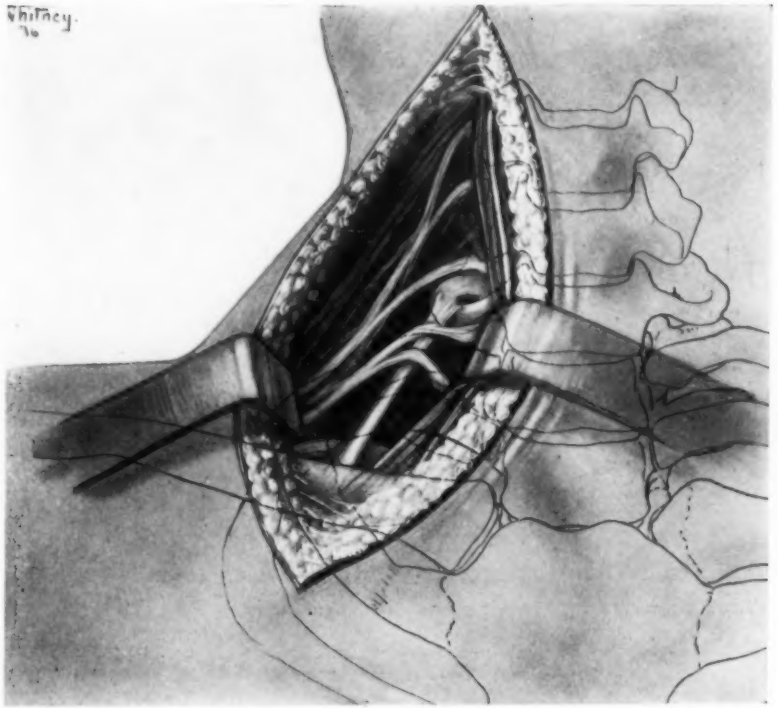

FIG. 2.—Schematic drawing showing angulation of lower cords of brachial plexus over adventitious ligament.

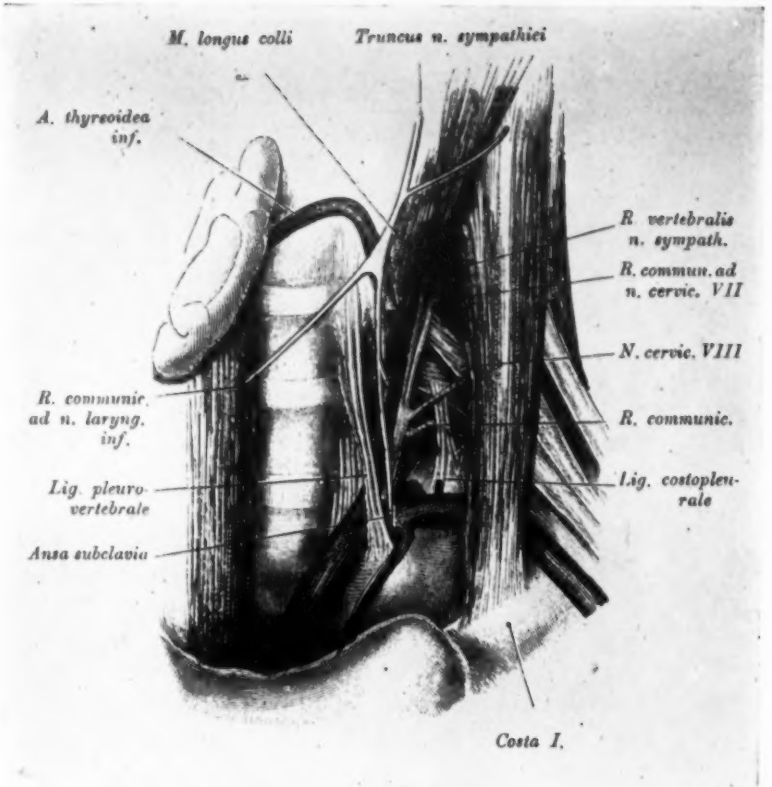

Fig. 206. Linke Pleurakuppel und deren Nachbarschaft.

FIG. 3.—Taken from Zuckerhandl showing Sibson's fascia and abnormal and inconstant ligaments inserted into dome of the pleura.

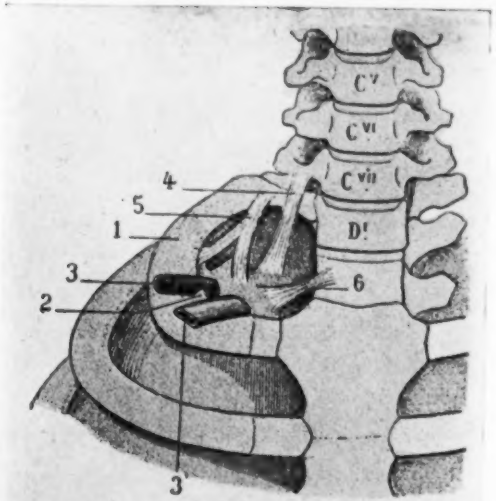

Fig. 766.

Appareil ligamenteux sus-pleural (d'après les dissections de Sébileau).

1, première côte. — 2, tubercule de Lisfranc. — 3, 3, artère et veine sous-clavières. — 4, ligament pleuro-transversaire. — 5, ligament costo-pleural. — 6, ligament vertébro-pleural. — CV, CVI, CVII, cinquième, sixième et septième vertèbres cervicales. — DI, première vertèbre dorsale.

FIG. 4.—Taken from Poirier and Charpy, showing abnormal bands inserted into the dome of the pleura.

FIG. 5.—Osteoporosis of phalanges of third and fourth fingers compared with normal and showing trophic changes due to pressure on brachial plexus.

The cases were equally divided between the sexes and the ages were forty-seven and forty-eight years in the males and nineteen and forty-four in the females. In each instance after operative interference, while the neuralgia persisted for a while, it promptly became less severe and ultimate and complete relief was obtained.

Searching the literature in an attempt to find an etiological explanation for these bands, we found that those springing from short cervical ribs were reported; the nearest description of anything resembling the complete ligaments is described by Zuckerkandel who, in his dissections, discovered that there were certain inconstant and extremely variable bands which have been associated with Sibson's fascia and which are occasionally found reënforcing and helping that fascia to fix the dome of the pleura. This fascia and associated fasciculi, according to Zuckerkandel and to the French observers, Poirier and Charpy, is derived in man from a tiny rudimentary, inconstant muscle, which itself is extremely variable in its origin, distribution, and insertion, the so-called scalenus minimus; this little muscle, unusual in the human, is normal to a number of the Simian species. These bands of Sibson's fascia as well have been designated according to their distribution as the pleuro-transverse, the costo-pleural, and the vertebro-pleural ligaments.

Whether the adventitious bands we have described are a remnant of supernumerary ribs, are a variation of the Sibson's fascia, or are in themselves a distinct entity has not been determined. We believe, however, that they should take their place and be recognized as structures which are actually as definite and give as plain a symptomatology as do cervical ribs themselves. A knowledge of their occasional presence may help to explain some of the circulatory and trophic conditions of the hand and arm of obscure etiology which heretofore from want of exact knowledge we may have designated as Raynaud's disease, intermittent claudication, spontaneous gangrene, or thrombosis.

The writer hesitates to report so meagre and so inconclusive a series of cases, but hopes that by so doing attention may be directed to a condition which, judging from the barrenness of the literature, must be relatively rare or rather generally overlooked.

SPERMATOCELE

By Edward T. Crossan, M.D.
of Philadelphia, Pa.

Spermatocele is accepted to-day as meaning a retention cyst of the scrotum, containing spermatozoa, and arising either from the vas efferentia, the canal of the epididymis, or from the embryonic remnants around and about the testicle and lower end of the cord. Like many other medical terms, it is not quite exact, for it is claimed that spermatocele can exist without spermatozoa, and furthermore there are a few cases on record in which the cyst extended beyond the external inguinal ring. In view of the varied opinions as to the genesis and etiology it would be better to define it as a cyst originating in the scrotum and which is, or has been, in communication with the semen-carrying system.

The term spermatocele appears to have been primarily employed by Guerin in 1785 in reporting an obscure inflammatory condition of the testicle, which in no way bore any resemblance to what is now recognized as spermatocele. In the literature of that period these cysts were doubtless diagnosed as encysted hydroceles.

In April, 1843, Liston wrote an article, the title of which was "Some Observations on Encysted Hydrocele." In this article he mentioned two cases in which the fluid withdrawn from these sacs contained spermatozoa. Two months later Lloyd reported three similar cases, the first of which was revealed when he was using some fluid from an "encysted hydrocele" to dilute blood for microscopical examination. These findings were confirmed by Paget, Curling, Sedillot, Gosselin and others, and though these proofs seemed to point toward a pathological entity, the term encysted hydrocele survived until 1860, when Cavasse used the term spermatocele as applying to cysts containing spermatozoa. The subsequent studies of this condition were conducted chiefly by the French and Germans, and to Dolbeau, Hanusa, Kocher, Luschka, Hochenegg, and von Hoffman we owe much of the information which we possess.

The American literature is very scanty on the subject. Ellis, in 1858, reported the finding of spermatozoa in hydrocele fluid. From that date until 1876 we find no further reports; in the latter year, Dr. William Hunt and Dr. John B. Roberts reported a case which had been diagnosed as hydrocele, but on aspiration they found the fluid was of a milky color, and the microscopical examination showed spermatozoa. Following the above records only an occasional report is found until 1907, at which time Whitney published a thorough review of the literature, and then comes a hiatus which extends to the present year.

To understand the origin and etiology of spermatocele, a review of the

relation of the epididymis and testicle, and of the embryonic remnants to the epididymis and testicle is quite essential.

The testicle hangs suspended in a space, the cavum vaginale, from which it is separated by the visceral layer of the tunica vaginalis. The latter is continued on to the epididymis, at the lateral margins of which it is reflected forward as the parietal layer, and as this is more extensive than the visceral layer, the above-named cavity results. The testicle is enclosed in a thick capsule of fibrous tissue, the tunica albuginea. The tunica albuginea sends prolongations inwards, dividing the testicle into lobules. Each lobule contains the seminiferous tubules, extending from the base where they end blindly, towards the apex, at which point they unite

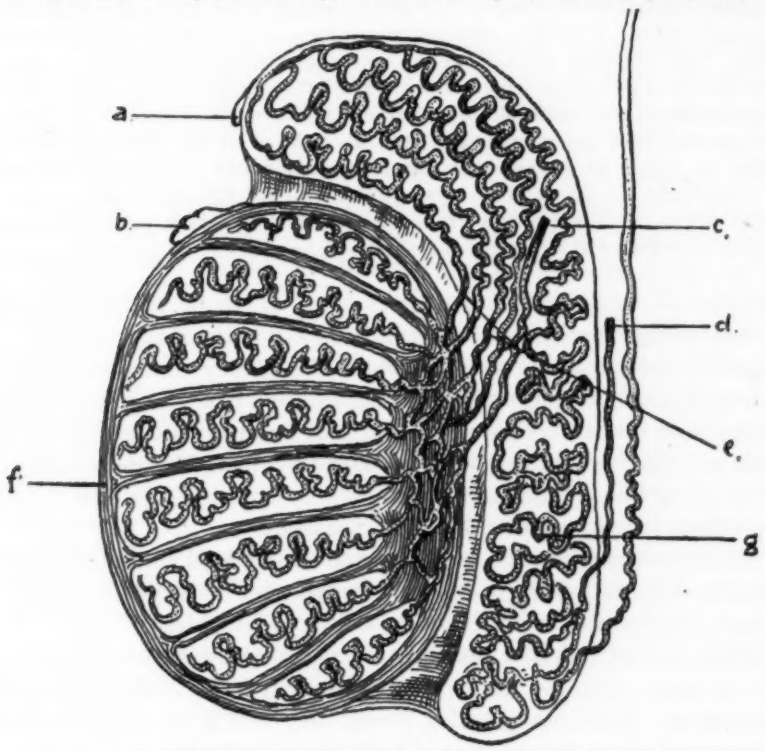

FIG. 1.—Diagrammatic sketch of relations of testicle, epididymis and embryonic remnants. *a*, pedunculated hydatid; *b*, hydatid of Morgagni; *c*, vas aberrans superioris; *d*, vas aberrans inferioris; *e*, vasa efferentia; *f*, testicle; *g*, epididymis.

to form the tubuli recti. The rete testis is formed in the mediastinum testis by the tubuli recti, and from it spring 12 to 15 vasa efferentia, which pierce the tunica albuginea and pass backwards in the ligamentum epididymis superioris, to form the coni vasculosi in the globus major. The canal of the epididymis arises from the coni vasculosi and at the cauda becomes the duct of the vas deferens.

The epididymis is attached to the testicle at three points by two-leafed folds of serous membrane, which are nothing more or less than the extension of the visceral layer of the tunica vaginalis on to the epididymis. The fold of the globus major is called the ligamentum epididymis superioris, and between its leaves pass the vasa efferentia. The double fold at the body encloses a space, the saccus epididymis. The ligamentum epididymis inferioris is the fold at the cauda.

There now remain to be considered the embryonic remnants, viz.: the hydatid of Morgagni, the pedunculated hydatid, the vasa aberrantia and the organ of Giraldes.

The origin of the hydatids is still in dispute. Luschka claimed that the sessile hydatid arises from the upper Wolffian tubules and the pedunculated hydatid from the Mullerian ducts. Virchow and Kocher claim that the sessile is a remnant of the Mullerian ducts. Stohr believed that the pedunculated is a representative of the Wolffian body.

The sessile hydatid is found at the upper pole of the testicle close to the globus major, and it has been stated by Kocher, Hochenegg, Lewin, and Luschka that there is a communication between the canal of the epididymis and hydatid. The pedunculated is attached to the globus major by a stalk; the stalk and head are usually solid. The vasa aberrantia are two in number, the superior and the inferior. The superior rises from the rete testis and ends blindly in the globus major; the inferior springs from the canal of the epididymis or from the duct of the vas deferens and ends blindly after extending up the cord about two inches. Kobelt proved that the inferior one was a remnant of the Wolffian body. Concerning the origin of the superior, there is some doubt; Langer-Toldt looked on it as a vas deferens that had lost its connection with the epididymis.

The organ of Giraldes is a group of vesicles and tubules situated in front of the vessels of the cord at the height of the globus major.

Origin.—Liston regarded the cysts from which he had withdrawn the fluid containing spermatozoa as enlarged seminal tubules.

Curling, Broca, and Paget advanced the theory that these cysts were neoformations. Curling and Broca maintained that the presence of spermatozoa was due to a rupture of seminal tubules into the cyst. Paget thought that the spermatozoa were produced by the epithelium of the cyst.

Following this, Follen and Verneuil produced the idea that this peculiar condition was a remnant of the Wolffian body.

To Virchow is given the credit for the theory held to-day, namely, that spermatoceles are retention cysts; however, he believed that they arose only from the vasa efferentia and the organ of Giraldes.

Kocher contended that the constant site of the spermatocele was at the vasa efferentia; that the latter structures offer a favorable location was confirmed by Hochenegg, who found the width of the seminiferous tubules to be 0.1–0.2 mm., that this diminishes to the size of the capillaries in the rete testis; in the vasa efferentia there is an expansion to 0.6 mm., followed by a contraction of 0.2 mm. in the coni vasculosi. This anatomical arrangement places the vasa efferentia between two obstructions, and as the testicle and globus major are covered with a dense capsule which would impede the formation of retention cysts, while the vasa efferentia are only surrounded by loose connective tissue, it is quite readily seen that dilatation of these ducts could easily occur. As a matter of fact, Dolbeau proved this experimentally by the injection of one hundred testicles with mercury, which caused a dilatation of the vasa efferentia.

The vas aberrans inferior has an origin similar to the vasa efferentia,

and since it has similar surroundings, together with the fact that it ends blindly, can be considered as a point predisposed to retention cysts. As far as the vas aberrans inferior, a retention cyst here would mean an obstruction of the duct of the vas.

If the hydatids or the organ of Giraldes are in communication with the semen-carrying system, the origin of spermatocele from these areas is quite possible. However, since the organ of Giraldes and the pedunculated hydatids are usually isolated, not very much credence can be put into any theory including these organs as the points of origin of spermatocele. From the clinical and anatomical data, it seems probable that the sessile hydatid is often involved.

Therefore, in summing up, it can be said that spermatoceles should arise most frequently from the vasa efferentia and vas aberrans superior, often from the sessile hydatid and only occasionally from the vas deferens, pedunculated hydatid and organ of Giraldes.

Causes—1. *Trauma.*—Gosselin was the first to give trauma as a cause, and later Hochenegg described the *modus operandi* of this factor. According to the latter, on violent concussion, the testicle, which is more or less mobile, is able to descend, whereas the epididymis, which is fixed, cannot follow the motion, and as a result there is tension on the folds of the serosa, and as the tension increases the vasa efferentia are torn. This laceration, he states, usually occurs where the vasa efferentia pierce the tunica albuginea; the ends obliterate and blind pouches are formed. Another method is given by the same author, namely, that on account of the very free blood supply, trauma may cause sub-serous bleeding, which becomes organized and converted into connective tissue, and as this shrinks later, the vasa efferentia or the canal of the epididymis are obliterated.

In support of the trauma theory, Hochenegg reported two cases; one in a man fifty-two years of age, in whom after a sudden fall a stinging pain in the groin was felt and followed six months later by spermatocele; the other, a boy of fourteen years, after lifting a heavy load, had a history similar to the above.

Princeteau, Verneuil, Krebs, and Bonneau reported spermatoceles following injury. In Bonneau's case it followed an operation for hydrocele. Krebs found trauma as a factor eight times out of fifteen cases.

2. *Sexual Abstemiousness.*—Cavasse reported the first case that gave rise to this theory, but it has neither strong clinical nor pathological support.

3. *Gonorrhœa.*—It is to be expected, of course, that to venereal disease would be ascribed a rôle in this condition. However, there is very little clinical evidence to support it, and yet why should it not be, particularly when the epididymis is involved?

Of the causes above named, trauma seems to be the most logical one, yet it must be of a peculiar variety, for injury to the scrotum is not rare, while spermatoceles are a curiosity. As before mentioned, it is quite logical to expect that gonorrhœa might be an etiological factor; however,

one cannot understand, in that event, why spermatoceles should not be as numerous as cases of hernia. In sexual abstemiousness, the overflow finds its way first to the seminal vesicles and then gains exit through pollutions instead of forming retention cysts.

Evidence has been produced to prove that spermatoceles are more numerous than suspected; Lewin found 8 of these cysts in 100 testicles of cadavers, while Hochenegg found 27 in 362 testicles of cadavers.

In the cases reported, the incidence seems to be equal on the two sides. They may occur at any age after the testicle has commenced to function.

Classification.—Von Hoffman divided them into intra-vaginal and extra-vaginal, though he claims that most of the extra-vaginal cysts commence intra-vaginally.

Extra-vaginal.—This variety arises from the vas aberrans superioris, from the vasa efferentia, and very rarely from the vas deferens and the paradidymis.

Those from the vas deferens and paradidymis are primarily extra-vaginal, whereas those from the other two, according to von Hoffman, become so by first occupying all the space in the ligamentum epididymis superioris, thereby displacing the epididymis backwards, and then they grow upwards in the tissues of the cord, when they become extra-vaginal. In this latter type of cyst the testicle is displaced downward and forward. The position of the testicle is unchanged in the variety arising from the vas deferens and the organ of Giraldes.

The site of insertion of the cysts arising from the vas efferentia and vas aberrans is in the rete testis; from the vas deferens and paradidymis, in the cord. The extra-vaginal cysts are usually unilocular. If multilocular ones are found, they are probably due to several cysts arising at the same time. The extra-vaginal cysts are larger than the intra-vaginal, and in one case reported by Stanley, 49 ounces were removed at the first tapping and 57 at the second. These cysts are supposed to have a pear shape, which when seen is characteristic, but the larger cysts take most any form. When seen macroscopically, it is noted that the walls of the cysts are thin and that distributed in the sac walls are fibrous cords, which when the sac is greatly distended cause bulgings, giving the balloon shape described by Savariaud.

Intra-vaginal.—These arise from sessile hydatid, or the canal of the epididymis, and project into the cavum vaginale. That these cysts do occur at the hydatid of Morgagni was demonstrated by Hanusa, who found, during an operation for hydrocele, a dilated sessile hydatid, the size of a cherry and containing spermatozoa. As the walls of the hydatid are very thin, rupture into the cavum vaginale can easily occur, giving rise to a hydrocele containing spermatozoa. The intra-vaginal cysts become intimately connected with the tunica albuginea, and as they grow they take on the form of the globus major. It is this latter character-

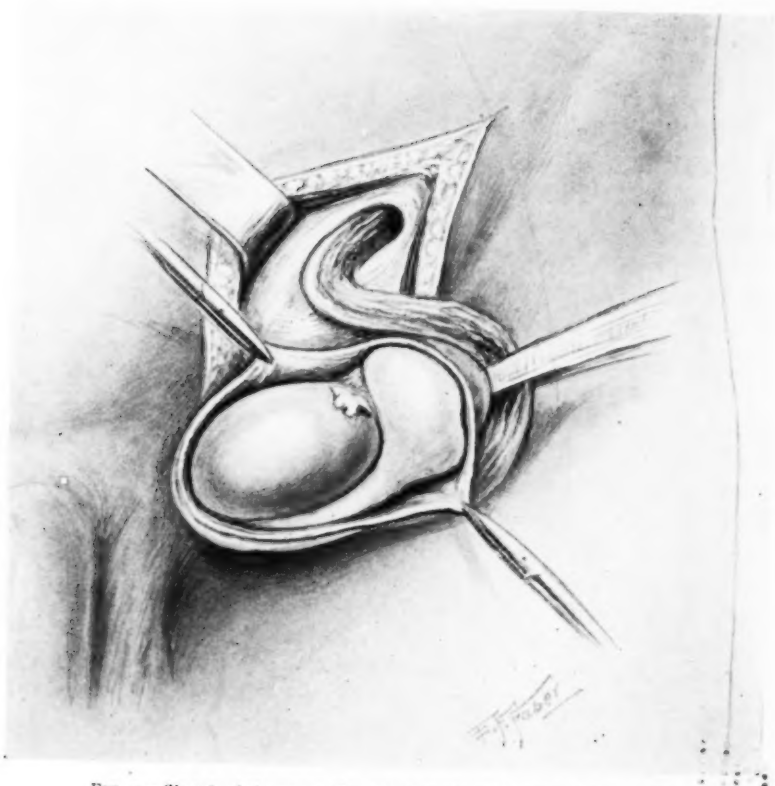

FIG. 2.—Sketch of the operation, showing the cyst at the globus major.

istic that gives rise to the impression that there is an accessory testicle superimposed on the normal organ.

Pathology—Structure.—The walls of the cysts are made up of interwoven strands of connective tissue, among which can be found bundles of smooth muscle. These bundles arise from the smooth muscle of the vasa efferentia and the canalis epididymis, and when found, it is claimed, surely point to the presence of spermatocele. The cysts are lined with ciliated or cylindrical epithelium when recent; in the older varieties the lining is of pavement epithelium.

Contents.—The contents are usually milky or soapy in color. On microscopical examination lymphocytes, fat globules, epithelial cells, and spermatozoa are found. The spermatozoa may be rigid or mobile, and in the cysts arising from a testicle which has become senile the spermatozoa may be absent. The fluid is feebly alkaline, has a specific gravity of 1.002–1.006, and contains 0.2 to 0.5 per cent. albumin.

Symptoms—Subjective.—There is a group of symptoms, which though rarely found, is pathognomonic, namely, severe pain in the testicle and swelling on sexual excitation. In the majority of cases there is no pain, only a feeling of distress. The swelling or tumor is what is most complained of, and if this is a slowly progressive affair following trauma, it would cause one to be suspicious of spermatocele. A certain number consult a physician, believing they have a third testicle, and as Liston says, "flatter themselves in thinking they are thus unduly provided."

Objective.—Here, too, the only finding will be a tumor. In the intra-vaginal variety it is a globular mass sitting on top of the testicle, but as sometimes occurs in this variety, a hydrocele may be coexistent and the tumor will not be recognized.

In the extra-vaginal cysts, the testicle will be found displaced downward and forward.

Diagnosis.—The history of trauma, followed by a slowly progressive tumor in the scrotum, would be circumstantial evidence. If a pear-shaped mass is found with the testicle displaced downward and forward, the diagnosis of extra-vaginal hydrocele is probably correct, as is also the finding of a globular mass on the top of the testicle, indicative of the intra-vaginal cyst. Presence of spermatozoa in the aspirated fluid is not a positive proof, for hydrocele may contain these elements.

Hochenegg resorted to chemical examination for differentiation of hydrocele and spermatocele fluid; spermatocele fluid, as stated above, is feebly alkaline, has a specific gravity of 1.002–1.006, and contains 0.2–0.5 per cent. of albumin, while hydrocele fluid is strongly alkaline, has a specific gravity of 1.020–1.040 and has from 4.4 to 7 per cent. albumin. No dependence can be put on the light test, as spermatoceles transmit light as well as hydroceles.

Treatment.—Aspiration, injection of irritants and incision have all been abandoned, as recurrences were frequent.

The radical operation is now performed. In the cysts arising from the sessile hydatid and the vas efferentia, a portion of the tunica albuginea must be removed and the defects covered with serosa. In the other varieties the cyst can be easily enucleated from its bed and the stalk ligated close to its base. If the testicle is atrophied castration is the logical procedure.

CASE REPORT.—L. O., aged eighteen years, male, white, was admitted to the Episcopal Hospital September 12, 1916, and discharged September 30, 1916.

Family History.—Negative.

Past Medical History.—Has not been ill since childhood. Denies venereal infection.

History of Present Illness.—For the past six years the patient has noticed sagging in the left scrotum, and for about the same period has noticed a tumor attached to the testicle. At first was the size of a pea, now has grown to the size of a walnut. On account of the tumor the patient was given the nickname of " Hock Shop." Never any pain in the testicle nor any interference with genito-urinary functions. Comes to the hospital to be operated on, as he wishes to enter the Navy and has been rejected because the Navy doctors said he had a " third testicle."

Physical Examination.—Scrotum: Varicocele left side. Attached to upper pole of left testicle at the site of the globus major, is a mass the size of a walnut. It is firmly attached to the testicle, and pressure over the mass is transmitted to the testicle. A diagnosis of spermatocele was made.

Operation.—September 15, 1916. Operator: Dr. A. P. C. Ashhurst. Assistant: Doctor Crossan. Incision over left inguinal canal three inches long. Fascia of the external oblique is split and the testicle delivered into the wound by traction of the cord. Tunica vaginalis seemed to be slightly distended and did not show any masses on the external surface. Tunica vaginalis is then opened and a few drachms of clear, straw-colored fluid evacuated. Tunica is split throughout its whole length, and it was then ascertained that the globus major showed a cyst the size of a lima bean. This was aspirated and about 4 c.c. of a milky fluid removed. The walls of the cyst were then opened. On opening the wall of the globus major it was found there was another cyst wall inside of it at a depth of 0.5 cm. This was dissected free and removed, having no dense adhesions. Portion of the wall of the globus major is removed for examination. Remainder is closed with No. 00 chromic catgut. Before the above procedure a small portion of the tunica vaginalis was removed at the upper angle. The tunica vaginalis is then closed with No. 0 chromic interrupted gut. It was impossible, however, to make the edges meet at the upper limit of the sac. Testicle and its covering are replaced into the scrotum. Varicose veins separated from the remainder of the cord and divided between ligatures, a length of about 6 cm. being excised, and stumps

approximated by tying the corresponding ends of the ligatures. External oblique is then closed by continuous No. 1 chromic catgut. The skin with No. 0 lock stitch of chromic gut. Dressings are then applied.

October 30, 1916: Discharged. Testicle is still swollen and tender on pressure.

Pathological Examination.—1. Cyst wall: Fibrous tissue wall, lined with columnar cells.

2. Fluid from cyst: 2 c.c. in amount, contained two spermatozoa, specific gravity 1.050.

Further History.—Patient was seen on March 2, 1920, at which time it was found that there was an atrophy of the left testicle. The latter was reduced to a mass 1½ cm. long by 2 cm. wide. The above unfortunate occurrence was probably due to some impediment at the globus major completely obstructing the semen-carrying system. Briaud produced a similar condition in rabbits by ligating the vas deferens.

SUMMARY

Spermatocele is a retention cyst of the scrotum which is or has been in communication with the semen-carrying system. The cysts arise most frequently from the vasa efferentia, the vasa aberrantia superiori, and the sessile hydatids. The main symptom is swelling, with sometimes a history of previous trauma.

I wish to express thanks to Dr. A. P. C. Ashhurst for permission to report the above case.—AUTHOR.

BIBLIOGRAPHY

Liston: Med. Chir. Tr., London, 1843, xxvi, 216–222.
Lloyd: Ibid., 368–373.
Guerin: J. de med. mil., Par., 1785, iv, 66–74.
Cavasse: Gaz. d. hop., Paris, 1860, xxxiii, 378.
Sedillot: Mem. de Sec. de med., Strasb., 1853, xiii, 33–42.
Ellis: Boston M. and S. J., 1858, lviii, 99.
Gosselin: Bull. gen. de therap., etc., Paris, 1852,, xliv, 110–112.
Baker: Edin. M. J., 1876–7, xxii, 1085–1087.
Bennet, E. H.: Irish Hosp. Gaz., Dub., 1873, i, 290.
Curling: Month. J. M. Sc., London and Edinb., 1848–9, ix, 1023–1027.
Hunt, W. B.: Phila. Med. Times, 1875–6, vi, 368.
MacDonnell, R. L.: Brit. Am. J., Montreal, 1860, i, 60–62.
Paget, J.: Med. Chir. Jr., London, 1844, xxvii, 398–404.
Ebert, Walter: Ueber Spermatocele, Leipz., 1902.
Von Hoffman: Ergebn. de Chir. u. Orthop., Berlin, 1914, viii, 698–701.
Whitney, C. M.: Am. J. Urol., N. Y., 1907, iii, 175–197.

A CONSIDERATION OF THE VARICOCELE OPERATION AND THE AVOIDANCE OF POST-OPERATIVE INDURATION *

By Penn G. Skillern, Jr., M.D.
of Philadelphia, Pa.

An undesirable sequel of operation for the cure of varicocele is the column of induration that frequently forms and that extends from the testicle upward through the scroto-abdominal passageway to the external inguinal ring. This column of induration may persist for several weeks, and to this extent the cure may be said to be worse than the disease. So disabling was this column of induration considered in recruits that in the first period of the World War official bulletins advised not to operate upon varicoceles unless they were of very large size and productive of symptoms. The writer had occasion to perform the varicocele operation in perhaps several dozen cases during the past three years, and the following observations are based upon the study of this series of cases.

The causes of this column of induration seem to be: (1) Limited resection of veins with end-to-end suture of stumps: this results in stagnation of blood in closed vessels, with a lump at the site of the stumps; (2) failure to obliterate the dead spaces established by dissection of the fascial layers: these dead spaces furnish room for the outpouring of blood and tissue juices after operation; (3) irritation of the vas deferens from rough manipulation: I have found the vas very sensitive to trauma, to which it reacts by swelling to several times its original size.

Many operations have been devised for the cure of varicocele, but to the writer it seems that there need be but one operation—an operation that will remove the disease and yet not be followed by the above undesirable sequelæ. No operation removes the disease which does not remove the entire mass of veins involved. No operation is satisfactory which does not obliterate dead spaces left remaining by mere edge-to-edge apposition of the divided fascial layers, or perhaps no suturing of these layers at all. No operation is satisfactory which brings about irritative reaction of the vas to trauma from rough manipulation.

The writer obtains satisfactory results as regards the above details by performing the operation as follows:

An incision is made over the inguinal canal as for herniorrhaphy, dividing skin, Camper's fascia, Scarpa's fascia, and the aponeurosis of the external oblique muscle, opening into the external ring. The cremaster muscle with its fascia is next divided and retracted, exposing the spermatic cord enclosed in the thin infundibuliform fascia. The part of

* Read before the Philadelphia Academy of Surgery, April 5, 1920.

the spermatic cord first seen is the anterior group of veins which are varicose, and which constitute the bulk of the varicocele. This anterior group of veins is picked up at the internal ring and freed from the infundibuliform fascia as far as the testicle below. During this manœuvre the anterior veins are drawn away from the posterior veins and vas, so that there is no occasion to disturb the vas in any manner whatsoever, nor even to touch it. By keeping away from the vas there will be no misgivings as to the integrity of the circulation of blood to the testicle *via* the deferential artery and veins, nor any as to the post-operative irritational swelling of the vas. While freeing the veins close to the testicle the tunica vaginalis may be opened inadvertently: such an opening, however, is not undesirable, for it prevents post-operative acute hydrocele formation in a closed sack. The opening, when made, should not be closed: it will heal of itself within a few days.

The anterior tortuous veins having been freed are ready for ligation. Removal of the entire pathology requires that these ligatures be applied at the testicle below and at the internal ring above. The thickest part of the varicocele is at the testicle, and the thinnest is at the internal ring, where usually but two veins are present to return the blood from the varicocele to the spermatic vein. In certain cases the varicocele extends into the inguinal canal, where it forms a bulge simulating hernia. The advantages of opening the canal are that such a varicocele extending into the canal may be dealt with, and also that isolation of the veins may be begun where the veins do not contact with the vas, *i.e.*, at the internal ring. The ligatures are applied as follows.

Using No. 1 plain gut carried by an aneurism needle the vein mass is transfixed close to the testicle and the suture is tied on both sides of the mass. A clamp is applied to the vein mass proximal to the ligature in order to prevent soiling of the field with blood escaping from the veins when divided, and the vein mass is divided between the ligature and the clamp. In similar manner the two veins at the internal ring are transfixed and ligated, care being taken not to pinch in the ligature the little pouch of peritoneum which appears anteriorly when the veins are freed close to the internal ring. For safety's sake a second ligature is applied close to the first, for if but one ligature be applied and should slip off, annoying retroperitoneal bleeding from the retracted stump would arise. A clamp is applied to the vein mass distal to the second ligature, and the veins are divided between the clamp and the second ligature. The vein mass between the clamps is now removed from the field: its length varies from four to six inches. The inguinal canal is now occupied by the vas with its vessels and the posterior set of veins, which usually are not varicose. The cremaster muscle with its fascia is now sutured snugly down upon the vas, this being accomplished by passing the sutures at a distance from the cut edges. If it is desired to draw the testicle to a higher position, the cremaster muscle with its fascia is sutured trans-

versely, although I have rarely found this step necessary. I may say in passing that I do not believe in shortening the scrotum by resection, for when an undue weight is removed from the scrotum, the latter contracts soon or late, when the dartos and cremaster muscles recover their physiologic tonus.

The retracted ilio-inguinal nerve is now replaced, and the incision in the external oblique aponeurosis is closed. Scarpa's fascia is closed as a separate layer and tacked down upon the external oblique aponeurosis, thus obliterating the dead space that otherwise would exist between these two layers, and also approximating the cut edges of Camper's fascia and skin. The skin is closed by interrupted sutures of silk-worm gut. After the dressing has been put on a suspensory is applied to the scrotum, and the latter is elevated over the pubes to counteract gravity.

Since employing the above technic I have not seen the column of induration arise. All the palpating fingers find after operation is the ligature stump at the top of the testicle and above this the normal-sized vas pursuing its course up to the inguinal canal. There may be a transitory enlargement of the testicle while the deferential vessels are establishing the compensatory circulation, but atrophy of the testicle is no more frequent than after orchidopexy for ectopia: indeed, it is very rare, and should not be as frequent as in the latter condition.

The patient is allowed out of bed in two days and discharged from hospital on the sixth day, cured of varicocele without undesirable sequelæ.

CUTTING THE BONE FLAP IN CRANIAL SURGERY

By Harvey C. Masland, M.D.
of Philadelphia, Pa.

Cranial surgery is resorted to for the treatment of traumatic conditions and for those the result of disease. In considering the question of opening the skull it is recognized that many cases, and particularly those of the traumatic type, must be treated by no set rule, but according to the indications present.

It is accepted as axiomatic that two motives should dominate one in performing any surgical operation. First, the objective desired should be gained with the greatest expedition, safety and facility. Second, with the first objective attained the tissues left should show the least mutilation and so promise the best possible physiologic and cosmetic end-results.

The method I wish to present follows the usual basic lines of procedure, but the instruments used are presented with the belief that they offer certain advantages in the performance of the operation and also secure better end-results.

The bone cutting is done quickly with safety to the soft tissues and under perfect control. There is minimum wastage of the bone, so that in replacement the bone edges are closely apposed and good mechanical protection is provided. The scalp flap remains adherent to the bone flap, thus guaranteeing the vitality of the resected bone. It is adapted to operate upon any portion of the cranial vault.

A brief reference to the advantages and defects of the more commonly used instruments might be appropriate.

The old trephines served their day and with the ability of the more modern implements to do better surgery in every way are justifiable in but a few restricted cases. The cylindrical trephine is more dangerous than the conical. Either one is very prone to cut the dura and brain at some thin part in the circumference of the cut. This tendency increases with the size of the trephine, owing to the greater likelihood of variability in the thickness of the skull. The button of bone retains no vital connection.

The Hudson linear-biting punch forceps, if properly used, will not injure the dura. It will make a vitally connected flap of any size or shape. There is a tendency of the punch to jam in the wall of the incision. It cuts slowly and with increasing tire to the operator, according to the density and thickness of the bone. It destroys so much bone that in replacement the bone flap does not touch the surrounding skull wall for support.

The power-driven spiral osteotome protects the dura, permits a vital flap of any dimension, and is a useful instrument. Ordinarily, the osteotome is directly attached to the motor and the operator must hold the

motor in his hands. Practice and skill are required with this unwieldy mechanism to give a sufficient degree of sensitive control. Such a spiral osteotome, to be sufficiently strong and yet reasonably slender, must have but a shallow cutting edge. Searing of the bone is inevitable. As with the Hudson punch, too much bone has been removed to secure any coaptation of the bone edges. This can be prevented by leaving the bone partially cut at a few points and by fracturing the inner table, leaving a supporting shelf.

The Gigli saw reduces the width of cut very considerably as compared to the preceding instruments. Considerable skill is required to use this saw without breaking. The preliminary openings should be numerous as the saw occupies the position of the chord of the inside arc of the bone. The greater the curve the more does the saw press upon the dura and brain. Thus the soft tissues are cut before the saw starts to cut the bone in the middle portion of the arc. As the saw is but a square steel wire twisted it loses its slight cutting edge quickly and then chafes rather than cuts.

The thin saw, whether the Doyen hand saw or the power-driven circular saw, gives the least wastage of bone that could be expected. A vital bone flap can be cut with these instruments which on reposition will have bone support from the apposed edge of the skull. When these instruments are used the procedure is to determine the thickness of the skull by making preliminary openings. Gauges for the saw are set to cut through the outer table and partially through the inner table. Herein arises one danger. There is no means of discovering an unexpected thin point, and consequently there is always danger of cutting the underlying tissue. Should the inner table not be severed sufficiently there is the possibility of splitting and separating the two tables of the bone.

The circular saw referred to is of the type where the saw is directly attached to the motor shaft without adequate guards against possible injury to the tissues. All these motors are high speed, and consequently the bone is seared, even markedly carbonized, immediately on contact of the saw and bone. A drip quickly cools but does not prevent burning of the bone. The unwieldy hold on the instrument requires much skill to gain a fair degree of control.

The addition of a new instrument to our armamentarium is justifiable when it facilitates the performance of an operation, when its use lessens the possibility of mishaps, and when the end-results are better.

The enthusiasm of one who claims any or all of the above features is to be weighed in the exacting balance of experience and fact. It is appropriate to state that this equipment has been used clinically in several hospitals in our city as well as experimentally in the performance of different bone reconstructive operations. The equipment is adapted to all general bone plastic work. Each tool has been planned to perform most efficiently the particular work required. The accompanying photographs

FIG. 1.—Preliminary openings made with Roberts trephine and Masland multi-tool handle.

FIG. 2.—Incision through the outer table. Note that the inside guard on the saw is removed and the outside guard adjusted to cut the outer table only.

FIG. 3.—The bone flap with soft tissue attached laid open. The dura is intact.

FIG. 4.—The flap replaced, showing the close approximation of the edges.

are of some experimental work done to illustrate the operation, the title of this paper. The instruments for opening the skull comprise the multi-tool handle and a quarter-inch Roberts trephine and a circular saw as illustrated in the photographs.

The Roberts trephine works upon the principle of the Hudson burr. It jams and stops the motor before injuring the dura. The only possible way to prevent this jamming is for the operator to rock his instrument and destroy the tight-fitting bony wall of the opening. These instruments are driven by a low-speed completely enclosed aluminum motor, and a flexible sterilizable cable. Cables formerly used were properly condemned for their irregular delivery of power. This cable is one taken from the industries and especially constructed to sterilize in boiling water. It is sufficiently heavy and strong to deliver steady power without back lash. It is strong enough to stop the motor. The low speed possible with a selective current motor obviates the burning of the bone.

In performing the operation the skin incision is preferably made as illustrated, though, of course, modifications can be made where indicated. The part to be fractured, however, should be reasonably narrow. The preliminary openings are made at the upper angles of the wound. The very small diameter of the trephine practically excludes the likelihood of any great variation in the thickness of the bone. The trephine should be held vertical to the bone surface.

For the next stage of the operation I prefer to use the saw with the inside guard detached. The outside guard is adjusted to cut through the outer table only. This bone incision marks my line of cut. It reduces the final cutting with the inside guard to the inner table. The bone cutting can be done safely using the inside guard alone, but the increased fineness of control has appealed to me as worth while.

The upper incision can be bevelled to insure a stronger support in replacement of the flap. There is no advantage in making a small flap.

After making the cuts through the outer table the outside guard is turned back out of the way, and the inside guard attached. With the thumb this guard is held rigidly wide open and the tip inserted in a trephine opening. The tip is so shaped as to separate the dura from the bone with ease. When the guard arm has advanced its length under the bone the power is turned on and the saw gently brought down upon the bone and through the bone to the guard. Drawing the saw backward and forward and dipping it a bit all the intervening bone is severed. The guard can now follow after the saw through the groove and the cutting can be advanced. Failure to cut any portion of the bone is instantly felt by the pressing forward of the thumb pressing on the finger tip of the guard. The thumb should press backward on the guard so keeping the tip firmly against the inner surface of the bone. The remaining bone is divided quickly.

When one wishes to go across a sinus or large meningeal vessel an absolute assurance of protection is gained by resorting to the method em-

ployed in making the primary cut at the trephine opening. The saw is lifted up and the guard tip used to dissect the vessels and all underlying soft tissues the permitted distance of the guard arm. The power is then turned on and the saw cuts this portion. If any lack of confidence or other indication exists this plan can be pursued throughout. The operator quickly gains a tactile sense, however, that assures him that the tip is sliding along the bared bone of the inner wall.

The rotation of the saw is in a direction to throw the débris away from the operator. Any kick that may occur from too hard application of the saw is backward into the region of safety.

The serrated edge of the fractured side does not permit a perfect replacement. This is sufficient to take up the wastage of bone at the opposite side and bring the bone edge in contact with its apposed cranial edge. A slight elevation is usual. In this connection it has occurred that where provision might be desired for a subsequent easement under internal pressure the bone flap might be sectioned longitudinally to give the effect of laths as they are applied on a wall. This would give a bone reinforcement in the flap and also allow for a stretch of the soft tissue.

To summarize the features of this operation and the instruments used. The preliminary openings, usually but two, are small. The relations of the power and of the construction of the trephine to the skull opening are so adjusted that the trephine must jam before penetrating the dura.

If the preliminary saw cut through the outer table is used the guard is immediately adjustable to the depth desired.

The inside guard is of a shape to secure easy separation of the dura, and there is fine tactile sense of its efficiency in this respect.

There is no burning of the bone and so the vitality of the exposed osteoblasts is preserved.

There is bone support for the replaced bone flap.

If a greater provision for internal pressure is desired the bone flap can be variously sectioned in vital fragments to gain the desired end.

TRANSACTIONS
OF THE
PHILADELPHIA ACADEMY OF SURGERY

Stated Meeting held April 5, 1920

The President, Dr. George G. Ross, in the Chair

TOTAL CYSTECTOMY—CONDITION OF PATIENT FIVE YEARS AFTER OPERATION

Dr. B. A. Thomas presented a man, forty-six years of age, who was exhibited before the Academy four years ago. The case has been one of particular interest in view of his present state of health, and the nature of the apparatus necessary for deviation of his urinary stream. To the best of the reporter's knowledge this is the only case that has survived, for any length of time, the operation suggested by Watson, of Boston, in 1906; namely, separate nephrostomies, followed by total cystectomy as a third operative procedure.

The patient is employed at present as a mechanic in the Pennsylvania Industrial Home for the Blind. He is able to care for his apparatus routinely. His drainage apparatus is shown in the adjoining cuts (Figs. 1 and 2). It at present consists of two catheters, held in position in the fistulæ with the aid of safety pins and adhesive plaster, and connected by metallic joints to rubber tubing leading to two rubber bag urinals. In this connection it is worthy of note that perhaps no drainage apparatus, in such cases, will be permanently satisfactory. In this case, in the beginning, Watson's apparatus was used, but was soon found to be too bulky and heavy and was strenuously objected to by the patient. Subsequently, one of the urine receptacles of Watson's apparatus was placed over the hypogastric region, suspended by an abdominal belt, to which rubber tubing led from silver-flanged tubes placed in the urinary fistulæ. These at first were bulbous on the inside and fenestrated, but owing to phosphatic incrustations, necessitating their cleansing from time to time, and the difficulty of removal, had to have their bulbous expansions cut off, the tubes then being held in position by adhesive plaster, placed over the external flanges.

This patient had his first cystotomy in January, 1912, for nodular formations at the apex of his trigonum. A few months later these nodular formations recurred, and he was treated in another hospital by fulguration, with little or no improvement in symptomatology. In October, 1913, the patient was admitted to the Polyclinic Hospital and with Young's cystoscopic rongeur two or three of the small intravesical tumors, which at that time completely filled the lower half and neck of the bladder,

varying in size from a small pea to a cherry, were removed and submitted to Dr. John A. Kolmer for histopathological examination, who reported them to be inflamed polypi. The bladder was opened and the interior thoroughly cauterized with the electro-cautery, care being taken to destroy all evidence of these multiple polypoid growths. A few weeks later cystoscopy showed recurrence of the growths, and in January, 1914, the left ureter was ligated close to the renal pelvis and nephrostomy under ether anæsthesia performed. Five weeks later the right kidney was treated similarly, under stovain spinal anæsthesia, and on November 6, 1914, total cystectomy under ether anæsthesia was done, together with religation of the left ureter, because the lumen of the ureter had become reëstablished. This ligation was done with silk; the first having been done with catgut.

Three months later the patient complained of pains in his prostatic region and perineum, of a severe character, and on the presumption that the polypi were reforming in the prostatic urethra, where a few had been previously observed, on March 23, 1915, a perineal extracapsular prostatectomy and total posterior urethrectomy were performed under ether anæsthesia, from which the patient convalesced remarkably satisfactorily. In spite of this strenuous surgical treatment, he is still living and in remarkable health.

INTRAPERITONEAL HERNIA OF THE ILEUM THROUGH A RENT IN THE MESENTERY

Dr. Henry P. Brown, Jr., in presenting the patient, said that from a fairly thorough review of the literature of the past twenty-five years it seems that hernia through a rent in the mesentery, while not being rare, is unusual. He had found reference to nineteen cases, to which he wished to add one that was admitted to Doctor Hodge's service at the Presbyterian Hospital, and upon which he allowed the reporter to operate.

The patient, a white boy of five years, was admitted to the hospital June 23, 1916. Chief complaint was pain in the abdomen and vomiting. While playing on June 21st he fell down two steps, striking on the dorsolumbar region. He was apparently uninjured and resumed play. That night he complained of abdominal pain and vomited a few times. He was given a dose of magnesium citrate which he vomited. On the 24th the vomiting and pain became more severe, and on the 25th a physician was called who diagnosed acute appendicitis and advised operation. His bowels moved the morning he fell, but not since. Although not complaining of much pain, the patient had the pinched features and fixed stare of a very sick boy. The abdomen was distended and very rigid. Peristalsis freely heard over upper abdomen. Tympanitic to percussion. Patient points to painful spot just below umbilicus, but no mass can be palpated. His leucocytes were 21,000 on admission; temperature, 101° F.; pulse, 140; respiration, 46.

Operation June 25th, third day after onset of condition. Ether anæs-

FIG. 1.

FIG. 2.

Drainage apparatus after total cystectomy.

thesia. Incision through outer border of right rectus muscle below umbilicus. On opening the peritoneum about one-half a litre of blood-tinged fluid escaped from the abdomen. A knuckle of twisted gangrenous gut, about 20–30 cm. long, presented in the incision, a coil of lower ileum which had passed through a 3-cm. opening in the mesentery, and had become twisted upon itself two and one-half times. The neck of the volvulus was cord-like in character. The opening in the mesentery, located about 5 cm. above the cæcum, had rough edges, apparently of recent origin. The gangrenous loop of ileum was resected and an end-to-end anastomosis was made with a Murphy button. The hole in the mesentery was closed, and the abdomen closed in layers. Hypodermoclysis was given. The patient died four hours after the operation.

A brief summary of the reported cases as collected from the literature is as follows:

Case I (Reported by C. G. Franklin).—Man seventy-three years of age. Admitted to the hospital with symptoms of intestinal obstruction. Five days before admission, while in bed, he was seized with sudden abdominal pain and vomiting. Slght action of the bowels. Vomiting daily, it becoming feculent in character two days before admission.

Operation day of admission: Coil of small intestine 6 inches long, tightly strangulated in circular aperture in mesentery. Opening enlarged, bowel reduced. It was deep red, port wine in color and deeply indented by the ring. Recovery.

Case II (Reported by J. G. Smith).—Boy of twelve years. Three weeks before admission had an attack of pain in right abdomen, accompanied by vomiting. Improved. Three days later another attack. Operation: Loops of strangulated intestine, very dark, through hole in mesentery. Easily reduced. Bloody fluid and serum in abdomen. Recovery.

Case III (Reported by J. S. R. Smith).—Girl of fifteen years. Seized with sudden abdominal pain soon followed by vomiting. Symptoms of intestinal obstruction followed and lasted till operation on the fourth day.

Operation: Bowel greatly congested, small loop of bowel in a hole in the mesentery 2½ by 2 inches. Bowel judged capable of recovery—reduced. Hole had smooth thick margins—congenital in type. No history of previous injury. Recovery.

Case IV (Reported by J. Clark).—Girl nine years old. Four years previously she had been run over by a trap. Went to bed feeling all right. Had sudden attack of abdominal pain and vomiting. When first seen fourteen hours after onset of attack, she was in a state of collapse. Complete intestinal obstruction. Death twenty-four hours after onset of attack. No operation.

Autopsy: Thirty ounces of bloody serum in the abdomen. Four feet of lower ileum had passed through an aperture in the mesentery, strangulated. Evidence of old peritonitis in this area of the abdomen.

Case V (Reported by A. P. C. Ashhurst.—Boy of twelve fell and hurt his hip. Next day, dietetic error. Pains in abdomen, vomiting. Symptoms of intestinal obstruction for three days. Abdomen distended, vomiting fæces, blood and mucus by bowel. Umbilicus suggested presence of Meckel's diverticulum.

Operation: Fecal smelling blood fluid—black coil of gut in pelvis resembled volvulus. Resected 14-18 inches of intestine—end-to-end anastomosis—glass tube in pelvis. Death three hours later. Hole in mesentery—ileum passed through till stopped by base of Meckel's diverticulum. Loop of gut was twisted and gangrenous.

Case VI (Reported by J. B. Deaver).—Sudden severe pain while cranking car—relieved in several days. Six months later while again cranking car had sudden severe

abdominal pain which did not subside. Admitted to hospital in dying condition. No operation. Post-operative examination: Strangulated gangrenous coil of intestine through a congenital hole in the mesentery.

CASE VII (Reported by W. A. Lane).—Boy of ten had sudden violent pain in central part of lower abdomen—vomiting. Thoroughly purged by family physician—two days later collapsed.. Complete obstruction of bowels—no previous history of injury or discomfort. Attack came on while asleep. In dying condition when admitted to hospital.

Operation: Second day after onset. Mass of dark bluish intestine 3½ feet long passed through ⅞-inch hole in mesentery. Lower end was 2 feet above ileocæcal valve. Opening was rough. Foul smelling bloody fluid in the abdomen. Patient died on the table.

CASE VIII (Reported by L. J. Mitchell).—Boy of eight fell down-stairs, landing on abdomen—apparently unhurt. Two days later complained of severe pain in abdomen. Diagnosed peritonitis by outside physician. No operation. Died four days later. Post-mortem examination: Opening in mesentery near ileocæcal junction, smooth margins. Several loops of strangulated bowel, dark cherry red in color, had passed through it.

CASE IX (Reported by A. B. Atherton).—Boy of fourteen years. Subject to attacks of abdominal cramps since six years of age. Present attack started with dietetic indiscretion—was well purged with calomel. Seen two days after onset of symptoms, which were those of obstruction. Died three days later.

Operation: Removed a twisted Meckel's diverticulum, which relieved the obstruction. Died three days later. Post-operative examination: Loop of ileum 1 foot long through hole in mesentery, 6 inches from ileocæcal valve. It was not gangrenous and was easily reduced.

CASE X (Reported by Mauclaire).—Woman twenty-one years. Signs of complete intestinal obstruction for five days. Mass palpated between umbilicus and pubes.

Operation: Strangulation of 30–40 cm. of intestine through hole size of palm of hand in mesentery. Margin of opening denoted that it was of long standing. She fell some days before the appearance of symptoms. Death ten hours after the operation.

CASE XI (Reported by E .C. Staab).—Woman of thirty-eight. Always suffered with constipation. No history of abdominal injury. Eleven days before admission she had severe abdominal pain which lasted five days, and ceased. Complete obstruction since first attack of pain. In state of collapse when admitted to hospital. Abdomen distended, not tense, no pain.

Operation: Large intestine collapsed from cæcum to sigmoid. On exposing small bowel, a portion slipped out of a hole in the mesentery. Circular hole in mesentery, ⅝-inch in diameter, 3 inches from cæcum. Blood supply to intestine was good. Died from collapse eight hours after operation. Post-mortem—nothing further was found.

CASE XII (Reported by F. W. Speidel).—Man shot by companion while out hunting, part of charge entering thigh and arm. While on way to hunt had sudden attack of cramps, and had a bowel movement. At the instant shot was fired, he threw up his hands and pitched forward on the ground. He had severe abdominal cramps which became more severe while on his way home.

Examination showed no evidence of wound to the abdomen. Pain one inch below and to right of umbilicus—vomiting bile. Was given morphine freely, in three hours he having received ten ½-grain doses by mouth and five ⅛-grain doses by hypo. "In short time he was given a dose of opium and in fifteen minutes he was quiet." Next day he was worse—obtained 2 ounces of urine per catheter. No vomiting. Bowels did not move since the accident. Calomel, oil and enemas failed to move him.

Operated on the eleventh day after onset of symptoms. Found a loop of intestine imprisoned in a hole in the mesentery—reduced. Patient died seven days later,

eighteen days after the onset, his bowels not having moved in that time. Fecal vomiting from tenth day to end.

CASE XIII (Reported by N. Macphatter).—Woman seventy-three years. No history of trauma. Complained of not feeling well—inability to move the bowels. On the fourth day she showed symptoms of acute intestinal obstruction.

Operation: Loop of intestine through mesentery—twisted—not gangrenous. Enlarged the hole in mesentery—reduced the bowel—closed the hole. Recovery.

CASE XIV (Reported by G. K. Dickinson).—Man forty-five years. Symptoms of acute obstruction.

Operation: General peritonitis. Hole in mesentery in region of cæcum—smooth margins—2 inches in diameter. A 2-inch coil of small intestine through the hole held in place by tip of gangrenous appendix.

Author does not mention duration of condition, condition of bowel, what was done, whether there was history of trauma or result.

CASE XV (Reported by W. D. Hamaker).—Woman seventy-two years. Obstinate constipation for many years. Sudden onset of symptoms of intestinal obstruction.

Operation third day after onset of acute symptoms: Meckel's diverticulum rolled up in one edge of gangrenous omentum. Rent in upper part of mesentery, through which passed all of transverse colon and omentum. Condition evidently of long standing. Opening was size of an egg. Removed Meckel's diverticulum and gangrenous omentum—reduced hernia. Recovery.

CASE XVI (Reported by C. H. Frazier).—Man thirty years. No history of trauma or dietetic indiscretion. Symptoms of acute obstruction.

Operated upon third day after onset. Exposed 18 inches of dilated congested small intestine, protruding through a slit in the mesentery. Easily reduced. Slit probably of long standing. He had an attack somewhat similar to the present one, thirteen years ago—vomiting, pain, constipation and cramps frequently since this first attack. Recovery.

CASE XVII (Reported by J. B. Roberts).—Man nineteen years. No stool for five days. Pain—distended abdomen Somewhat similar attack one year previous. Symptoms of acute obstruction.

Operation: In ileocæcal region, small intestine entangled in an opening in the mesentry—easily reduced—no gangrene. "There was apparently no actual protrusion of a loop through the mesenteric opening, but the bent intestine was seemingly thrust into the orifice in such a way that the sharp bend closed the lumen." Orifice seemed congenital. Recovery.

CASE XVIII (Glovanoff).—Incarceration of intestines in aperture of mesentery in closure of vitello-intestinal duct. Recovery.

CASE XIX (Herczel).—Intestinal incarceration with double volvulus in mesenteric opening. Operation. Recovery

Of these 20 cases, 3 that showed strangulation recovered. Seven with strangulation died. Two without strangulation died. Six that were not strangulated recovered. In one, the condition of the bowel and the result are not mentioned.

In no case was the condition diagnosed before operation. One condition of bowel not mentioned (gang?) died.

REFERENCES

[1] Franklin, C. G.: Lancet, London, 1894, i, p. 334.
[2] Smith, J. G.: Brit. M. J., 1897, i, p. 1022.
[3] Smith, J. S. R.: Lancet, London, 1897, ii, p. 1111.
[4] Clarke, J.: Brit. M. J., London, 1905, i, 594.

[6] Ashhurst, A. P. C.: Annals Surg., Phila., 1910, i, p. 34.
[7] Deaver, J. B.: Surg. Gyn. Obst., 1920, vol. xxx, No. 1, p. 30.
[8] Lane, W. A.: Brit. M. J., London, 1890, i, p. 890.
[9] Mitchell, L. J.: Annals Surg., Phila., 1899, xxx, p. 505.
[10] Atherton, A. B.: Brit. M. J., 1897, 2, p. 975.
[11] Mauclaire: Bull. et Mem. Soc. Anat. de Par., 1899, lxxiv, 247.
[12] Staab, E. C.: St. Thomas Hospt. Reports, London, xxi, p. 172.
[13] Speidel, F. W.: Louisville Med. Monthly, 1895-96, ii, p. 479.
[14] Macphatter, N.: Am. J. of Surg., 1904-05, xviii, p. 232.
[15] Dickinson, G. K.: J. A. M. A., 1907, xlviii, No. 15, p. 1267.
[16] Hamaker, W. D.: J. A. M. A., 1914, lxii, p. 204.
[17] Frazier, C. H.: Phila. Med. Jour., 1899, iii, p. 174.
[18] Roberts, J. B.: Therapeut. Gazette, Philadelphia, December, 1915, p. 1964.
[19] Glovanoff: Voyenno Med. J., St. Petersburg, 1901, lxxix, med. spec., p. 1964.
[20] Herczel: Orvosi betil, Budapest, 1897, xli, 42.

LARGE STONE IN THE BLADDER REMOVED BY SUPRAPUBIC CYSTOTOMY

Dr. George Erety Shoemaker presented a calculus and reported the case of a man, aged sixty-nine years, whose history was as follows: A rectal abscess was incised by his physician some four years ago, since which there has been occasional discharge of pus, and soreness in the perineum. Bladder symptoms have been confused by the patient with the rectal disorder, but for two years there has been increasing difficulty in urination with pain in both groins referred to rectum, down the thighs to the perineum and glans. The patient sits down cautiously, sidewise. Urination every one or two hours with much straining; it is accomplished only in the standing position with both knees bent and the right hip lowered. This peculiarity of position evidently gives a mechanical advantage over the obstruction.

X-ray and metallic sound demonstrated a large stone very low down and fixed. Only two ounces of fluid could be introduced, owing to the violent straining developed, and because of the valve-like action of the stone only a portion of the fluid introduced could be withdrawn by either a soft or hard catheter. There was a moderate amount of acidosis present; the heart was slightly irregular; there was some cough. The blood urea nitrogen was 14 and 7/10 mg. per 100 c.c. The phenosulphonephthalein test was 5 per cent. first hour, 8 per cent. second hour; total, 13 per cent. in two hours. The urine showed but little blood. The organisms present were staphylococcus and streptococcus of low virulence.

Because the bladder was contracted upon the stone which extended above the accessible point of drainage, it was felt that preliminary drainage would be unsatisfactory as a means of preparation for the strain of operation. The preliminary treatment was therefore confined to irrigation, somewhat imperfect, and a milk diet.

Conditions having improved, the p. s. p. test being now 30 per cent. in two hours, suprapubic extraction was done under gas ether. The peritoneum was successfully reflected without injury, assisted by

the introduction of a finger within the bladder. The surface of the stone was rough and friable, some scales adhering to the pocket behind the prostate where the stone was firmly adherent. The scales were carefully picked off and the wound closed down to a drainage tube. A daily irrigation was followed by one ounce of mercuro-chrome 220 one-per cent. solution which was left in the bladder. The drainage tube was out the fifth day. The bladder sinus was closed and normal function fully established the twenty-fourth day. The patient was discharged entirely comfortable, rising not more than once at night and holding the urine from five to six hours. A letter received a few days ago states that he is free from pain or distress; that the urine is clear and free from sediment, and that he rises once in the night. There is no leakage.

Of possible interest in connection with the origin of this stone is the fact that the patient was engaged in business in the far interior of the Honan Province of China some years ago, a region in which stone in the bladder is common. The weight of the stone was 313½ grams when removed. It has been sawed asunder and apparently contains no nucleus. It is composed of calcium oxalates and phosphates.

It may be mentioned that the use of mercuro-chrome appeared to contribute to the comfort of the patient and the freedom from infection during a smooth convalescence.

Dr. Alexander Randall presented a calculus which he thought was probably the largest human vesical calculus removed in modern times. The specimen belongs to Dr. Elmer E. Keiser. The patient was a foreman carder in a woollen mill, sixty-one years of age, slightly built, of medium height, and the father of ten children, the youngest of which is but four years old. Twelve years ago he passed by the urethra several small stones, since which time he has complained of frequency of urination, constipation, hemorrhoids, and has noticed hæmaturia on a few occasions. He likewise complained of a large hernia and great difficulty in properly retaining it. He consulted Doctor Keiser on July 17, 1919, having worked up to the first of that month. His complaint was severe constipation and difficulty with his hernia. On examination a hard tumor was found occupying the lower abdomen and extending from the symphysis pubis almost to the umbilicus. A hard catheter on introduction to the bladder grated on a surface that was believed to be a calculus, and withdrew one and a half ounces of clear urine that gave no evidence of blood, albumin, or sugar. An X-ray showed a remarkable shadow that was believed to be an osteoma of the pelvis. Operation was delayed in the hope of building up the patient's condition, but with no improvement operation was decided upon as a life-saving measure, and was performed on August 11, 1919, by Dr. Wm. H. Morrison at the Holmesburg Hospital, Philadelphia. The peritoneal cavity was not opened, the bladder wall was found markedly thickened, the stone firmly fixed in the pelvis. The patient died thirty-six hours after operation. The calculus

weighed on removal and in its moist state exactly 64 ounces, or four pounds: in its largest circumference it measures 48 cm. and in its lesser 40 cm., the deep impression with the ebonized surface is the imprint of the symphysis, while on the back can be seen the outline of the sacrum and the course of the rectum. The largest human vesical calculus removed as recorded by Gould and Pyle in "Anomalies and Curiosities" is that of Buffen found in 1739, and weighing over six pounds. In modern surgical literature the largest is that reported by Janeway in the *N. Y. Med. Jour.* in 1877 that weighed 51 ounces. Emerson C. Smith in *Surg., Gyn. and Obst.*, November, 1919, reports the successful removal of a stone weighing 38.5 ounces, probably the largest one removed without death. Sir Henry Thompson's "Catalogue of Collection of Calculi," published in 1893, reports numerous specimens of varying size up to 51 ounces. This stone now presented in its dry state weights to-day 56 ounces, and as far as we have been able to discover, is the largest specimen of authentic record.

THE VARICOCELE OPERATION

DR. PENN G. SKILLERN read a paper with the above title, for which see page 508.

GUNSHOT INJURIES TO THE CHEST

DR. GEORGE J. HEUER (by invitation) presented a paper, illustrated by lantern slides, with the above title, for which see page 352, September ANNALS OF SURGERY.

DR. JOHN H. GIBBON said that in probably no field of surgery, excepting joints, has there been greater advance than in the treatment of gunshot wounds of the chest. Of the very distinct lessons that surgeons can draw from their own war experience and that of others in regard to gunshot wounds, the most striking thing in the presentation of Doctor Heuer's communication is the results obtained in those patients not operated upon, and they constituted a large majority of the whole series. Another notable thing was the comparatively small percentage of cases of those not operated upon which required operation later and in this lies one of the lessons that we must apply in civil practice. There are very few simple penetrating wounds of the chest in view of this experience that would require immediate operation. One of the most difficult things one had to do was to get away from the habit of operating on these cases and to prevent others from operating upon them. Although we laid down the rule very often, he saw many cases of penetrating wound operated upon that had none of the indications for operation given by Doctor Heuer. To operate and drain means infection and always will. As to the remarks of Doctor Heuer as to what happens to cases in which the skin was not sutured, in a British base hospital in 1917, the speaker saw many cases of joint, abdominal and chest wounds that had been apparently properly treated which healed promptly and in which late infection took place under the skin, and required opening up afterwards; in the chest and joints infection of

the underlying cavities occurred. The abdominal cavity was not infected because the adherent omentum protected it. Therefore he concluded it would be a good plan to leave the skin open in these cases and later did so in a number of cases at a British casualty clearing station. He is now convinced that was a mistake. Doctor Heuer shows the cases did badly when the skin was closed. In regard to anæsthesia, he thought that all these infective cases, cases that were not operated upon at once and became infected later, should be operated on under local anæsthesia. Practically all the cases Doctor Heuer reports were drained under local anæsthesia. It is similar to operations in empyema which should be always done with local anæsthesia. One of the types of cases most instructive was combined abdominal and thoracic injury. Doctor Heuer reports a number of cases operated upon, although the abdomen was penetrated, in which there was no perforation of the abdominal viscera. They had a number of these cases in his evacuation hospital in which the abdomen had been penetrated and yet in which no operation was done and in which the patient got well. They established the rule there that if we were fairly certain that a hollow viscus had not been perforated and the chest wound did not require operation, no operation should be done. These cases were a great deal better left alone. Hemorrhage of the liver from gunshot wounds takes better care of itself than the surgeon can. When he starts in to stop it he usually makes it worse. These cases require the exercise of the best surgical judgment to determine those which should be operated upon and those which should not.

Dr. George J. Heuer in answer to the question regarding the expectant treatment of certain combined chest and abdominal injuries, said that in a series of thirty-nine combined chest and abdominal injuries, six cases were treated expectantly. In five of the cases the foreign body was embedded in the liver. Four of the six cases recovered; two died, one of gas gangrene of the leg, the other of lobar pneumonia of the lung opposite to that injured. Regarding the occurrence of hemorrhage and bronchial fistula during the process of sterilization of infected hæmothorax or empyema in fifteen cases of infected hæmothorax under his care abroad, neither hemorrhage nor bronchial fistula occurred following the use of Dakin solution irrigations. In the empyemata of civil life he recalled four cases in which hemorrhage had followed the irrigations. It has been rather interesting to note that hemorrhage in these cases has occurred late, at a time when sterilization of the cavity has almost been accomplished. Bronchial fistula has developed in the course of the irrigations in two cases.

TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

Stated Meeting held April 27, 1920

The President, Dr. William A. Downes, in the Chair

FRACTURE OF THE LOWER END OF THE RADIUS, WITH FORWARD DISPLACEMENT OF THE LOWER FRAGMENT

Dr. H. H. M. Lyle presented two cases of fracture of the lower end of the radius with forward displacement. He stated that the first patient, a woman, aged fifty-six years, was admitted to the Out-patient Department of St. Luke's Hospital, in the care of Dr. Julius Arnowich, with the diagnosis of Colles' fracture. She gave a history of having fallen on the back of her hand. The X-ray picture showed that instead of a backward displacement there was a forward displacement of the carpal fragment.

The deformity was reduced under gas and immobilized in moulded plaster splints.

Twelve days after the original injury the splints were removed and the wrist strapped with adhesive, bandaged, and supported in a sling. Gentle massage was also instituted. Four days later an X-ray check showed that the carpal fragment had become displaced forward. The fragment was again reduced and splints reapplied. A series of X-ray checks proved the fragments to be in good position. Eighteen days after the second reduction all the splints were removed. The patient had a good anatomical and functional result.

The interesting points in this case were: (1) The rarity of the fracture. Doctor Hitzroth showed a case before this Society and called attention to the extreme rarity of the condition. (2) Absence of crepitus. (3) Difficult of reduction. (4) Tendency to recurrence. (5) Cause, fall on the back of the hand.

The second patient, Doctor Lyle said, showed non-union after sixty-nine days, and gummatous infiltration thirty-three days after reduction. One week before admission to St. Luke's the patient slipped and fell backward. His hands were behind him and he struck on the dorsal aspect of the right hand. He noticed that his wrist was swollen and painful, but there was no loss of function. The patient had been under treatment in the hospital for spinal lues, and for a dilatation of the arch of the aorta.

On examination there was a well-marked prominence on the back of the wrist and opposite it a depression on the palmar side. The styloid

of the ulna was unusually prominent. There was a false point of motion, but no crepitus. The X-ray plate showed a fracture of the lower end of the right radius, with displacement forward of the carpal fragment (Fig. 1).

The deformity was reduced under gas and oxygen, a good result being obtained. Three days later the fragment became displaced. It was again reduced and immobilized, this time for thirty days. Thirty-three days after the reduction the patient appeared at the hospital with a swollen and inflamed wrist. He had a temperature of 103° and a pulse of 110, all the local signs pointing to an inflammatory process. An incision was made over the dorsal aspect of the swelling. No pus was obtained, but a thick, red grumous material was encountered. X-ray examination showed that the lower fragment had again become displaced. Energetic antisyphilitic treatment, both local and general, had greatly reduced the inflammatory mass. There was a certain amount of bony growth in the surrounding tissues, but no union.

CONGENITAL DEFECT OF THE SEVENTH CERVICAL VERTEBRA. FIBROUS ANKYLOSIS OF RIGHT SHOULDER-JOINT

Doctor Lyle presented a man who was referred to his service at St. Luke's Hospital by the Neurological Department of the Out-patient Department. He had been uncertain in his gait for seven months. He was unable to walk in a straight line. Last October he fell, striking his right shoulder against the curb. The shoulder did not trouble him until a month later; then he began to notice an aching pain in the shoulder if the arm was kept in one position. The pain often awakened him in the night. The onset of pain was accompanied by an increasing limitation of motion. Abduction was limited to 90° and rotation greatly reduced.

The X-ray examination of the neck showed a failure of closure of the posterior arch of the seventh cervical vertebra, the gap being 2.5 cm. wide. The right shoulder showed an atrophy of tissue. No bony lesion was made out. The blood and spinal Wassermann were negative. The luetin was negative.

At operation under gas and ether the adhesions in the shoulder-joint were broken up and free passive motion established. The patient was then returned to bed and the arm suspended from the author's frame in a position of abduction and external rotation. Active motion was begun as soon as the patient recovered from the anæsthetic. The position and active exercises were maintained for forty-eight hours. At the end of this period the patient was allowed up and the treatment of massage and active motions was maintained for two weeks. The patient at the present time has a perfect motion of the shoulder-joint.

The chief interesting point in the case, other than the congenital defect, Doctor Lyle said, was the immediate after-treatment of the stiff and painful shoulder. Early and persistent supervised active movements

of the involved joint would give perfect functional results in the majority of suitable cases. Doctor Lyle emphasized the fact that to insure a good functional result the patient must be under the control of the surgeon for the first forty-eight hours.

OSTEITIS FIBROSA OF FIBULA

Doctor Lyle presented a third patient who gave a history of having had a dull pain over the outer upper third of the left fibula for six months before coming under observation. For the first four months this pain was irregular. During the last two months it had been severe and constant. The leg had not been swollen. There was no history of trauma, infection, or lues. The Wassermann and luetin tests were negative. Antispecific treatment had no influence on pain or growth.

At the junction of the upper and middle third of the left fibula there was a smooth, hard swelling the size of an almond. There was a localized swelling in the outer border of the fibula 3 cm. in extent, involving the upper third of the bone, apparently representing a persistent lesion of benign nature. X-ray examination of the skeleton was negative.

Operation March 4, 1920, at St. Luke's Hospital. Under ether the swelling was exposed, the periosteum reflected, and a raised area 1.5 by 2 cm., composed of dead bone, was found. This area was chiselled down to the cortex of the fibula and an exploratory incision carried into the medullary cavity. Nothing suggestive of infection being found, the wound was closed.

Pathological report stated that the section showed a very small fragment of bone, and continuous with it smaller isolated areas in which there was a very active bone production with irregular calcification. The osteoblasts were numerous, but not unusually large, and the fibrous tissue intervening between these fragments was only moderately cellular. There was an occasional giant-cell, which somewhat resembled an osteoblast. The bone was not vascular. There was no necrosis, and it did not suggest an active tumor process, and was probably to be considered as an osteitis fibrosa.

The points of interest were: (1) A local progressive growth of bone, probably an early stage of osteitis fibrosa. (2) Pain was a prominent symptom. This was unusual in osteitis fibrosa. (3) The process seemed to be confined to one bone.

END-BEARING STUMP FORTY YEARS AFTER

Doctor Lyle presented a patient who had his leg amputated 2½ inches below the knee forty years ago by Stephen Smith. The X-ray of stump showed what excellent condition the bone was in. There was practically no bone atrophy. Despite the shortness of the tibia the patient practically bore all his weight on the end of the stump. The knee-joint having been retained, the jar of weight bearing is materially lessened (Fig. 2).

FIG. 1.—Case II.

FIG. 2.—End-bearing stump forty years after the amputation. Note the excellent condition of the bone.

Doctor Lyle showed this case for the following reasons: (1) The excellency of the anatomical and functional result. (2) Forty years of use had proven that this end-bearing stump had given a splendid functional result. (3) The value of retaining the knee-joint, even if the stump was short, was clearly shown in this case.

Lately there had been a tendency to decry the end-bearing stump, and also to disregard the great value of maintaining the knee-joint. Hasty conclusions drawn from observing stumps for a short period of time had led to many dogmatic statements which could not be substantiated. The early functional physiological use of a part was the best protection against future trouble. Of all the stumps, an end-bearing one was the best, and no joint yet devised by any artificial maker could take the place of the knee-joint. Lately the author had seen several indirect-bearing stumps that were originally considered perfect; some of these had relapsed into useless painful stumps. As time went on, Doctor Lyle said, more and more of this aftermath of the war would be met.

ACUTE ILEUS

Dr. Ellsworth Eliot, Jr., presented a woman who five years previously had had a hysterectomy. She was well thereafter until three days before admission to the hospital, when she developed the usual symptoms of acute obstruction, namely, severe paroxysmal pain, vomiting, and obstipation. The intestine, however, both by auscultation and palpation, showed signs of peristaltic activity. As a large colonic irrigation failed to produce any result, the peritoneal cavity was opened after excision of the old scar to which the small intestine was found adherent. The acute cause of the obstruction was volvulus of the small intestine, from right to left, the rotation taking place around the adherent intestine as a pivot in such a way as to constrict several feet of intestine beneath the free edge of the mesentery. With the untwisting of the volvulus, after division of adhesions, the obstruction was relieved. Examination then showed a loop three to four feet in length, distended and ecchymotic, but without loss of its glistening appearance or its resiliency. It was returned into the abdominal cavity and the wound closed without drainage. The patient had an interesting post-operative course. For the first five days she had occasional vomiting, especially after fluids by mouth. She received, therefore, fluids chiefly by clysis and the Murphy drip. She also showed a very peculiar mental condition of apathy and slept most of the time, although she could be roused. The urine was much reduced, there being no more than a daily average of 500 c.c. There was a trace of albumin, but no casts. A decided change took place after the sixth day; the patient became clearer in mind and lost her apathy, she retained large amounts of water by mouth, and the appetite improved. The general condition became rapidly normal, and she was discharged on the eighteenth day post-operative.

In this particular instance the degree of constriction, though impairing the circulation of the imprisoned gut, was not sufficient to produce any induration of the intestinal wall, and there was no sharp line of demarcation between the obstructed and non-obstructed intestinal segments. The absence of this more severe form of obstruction accounted for the fact that at no time either before or after operation was there any evidence of shock. It also accounted for the presence of exaggerated peristalsis noted on physical examination prior to operation and demonstrated after operation by the early action of the bowels. It would appear that the occasional vomiting and decided mental apathy in the absence of any post-operative discomfort or distention were due, in part, at least, to the absorption of the toxic contents of the obstructed intestine.

ACUTE ILEUS

Dr. Frederick T. van Beuren presented three patients to emphasize the difference between the severity of ileus with and without interference with the mesenteric circulation, and to illustrate the difference between the effects of immediate drainage and delayed drainage, and the benefit of the former.

The first patient entered the hospital January 1st with a history of vomiting for two weeks and no bowel movement for four days. There was marked distention of the whole abdomen, the colon being clearly outlined. The vomiting was fecal in character. A diagnosis of obstruction of the sigmoid by new growth was made and immediate operation performed. Median incision was made under local novocaine with morphine hypodermically. An annular growth was found in the middle of the sigmoid with enormous distention of the intestines above it. There was no interference of the mesenteric circulation. A puncture was made 1 inch above the constriction and 2000 c.c. of fluid suctioned off. The sigmoid with the new growth was mobilized and brought out through a left colostomy incision near the anterior superior spine. A little nitrous oxide gas was given to secure relaxation and the median wound was closed. A rubber-tube drain was placed in the sigmoid just above the constriction. Fourteen days later the externalized sigmoid with the neoplasm was removed. Later the spur was cut down by clamps and the colostomy wound closed by suture about three weeks ago. The patient made a very smooth recovery, ceased to vomit after the operation, and took water freely by mouth, requiring no hypodermoclysis. She was an excellent example of the beneficial effect of immediate drainage of the obstructed intestinal fluid.

The second case was that of a woman who had had a right inguinal hernia for many years. It began to pain her three days before admission. She had had no bowel movement for two days, and vomiting had commenced twelve hours before admission. It continued frequently and she said the vomitus had a very bad taste. On admission her distention was moderate and her condition fair. The hernia was operated immediately

under local anæsthesia, and the intestine found to be in good condition with slight circulatory disturbance, which was relieved by division of a constriction in the sac itself. The intestine was returned and the hernia repaired without removing any intestinal contents. The result was the transformation of a mechanical ileus into a paralytic ileus. The patient's distention was not relieved and she vomited twenty-four hours after her operation. The stomach tube then recovered 60 ounces of foul-smelling fluid. Forty-three ounces were recovered the next day, 22 ounces on the third, 11 ounces on the fourth, and 7 ounces on the fifth day. She retained nothing given by mouth for five days and had no bowel movement until the fifth day after operation, although enemas, colon irrigations, and pituitrin were administered. She required the replacement of water by hypodermoclysis, between 1000 and 2000 c.c. every day, until the vomiting ceased. After one week her recovery was uneventful, but up to that time she illustrated very clearly the bad effects of failing to remove the stagnated intestinal contents.

The third case was that of a man who had had a left inguinal hernia for three or four years. Four days before admission it began to pain him. He had had no bowel movement for twenty-four hours before admission, and he began to vomit twelve hours before admission. Owing to a mistake in believing that the hernia had been reduced, operation was delayed for sixteen hours after his admission. At operation his distension was well marked, and incision under local anæsthesia exposed 4 inches of gangrenous intestine, which showed no signs of recovery after division of the constricting hernial ring. Fourteen inches of intestine was resected, anastomosis being made by Murphy button, and the hernia repaired.

The patient vomited once after operation; otherwise he made an uneventful recovery. His bowels moved on the third day, and the Murphy button was passed on the twelfth. Although he was obstructed a shorter time than the first two patients shown, the mesenteric circulatory obstruction gave him more severe symptoms and caused gangrene.

RELATION BETWEEN INTESTINAL DAMAGE AND DELAYED OPERATION IN ACUTE MECHANICAL ILEUS.

Dr. Frederick T. van Beuren read a paper with the above title, which will appear in the November number, Annals of Surgery.

Dr. Adrian V. S. Lambert said he had watched this series of experiments with considerable interest. The dogs in which there were few symptoms for a long time were very instructive. The absence of symptoms which were associated with acute ileus was very striking. At the Presbyterian Hospital a series of examinations of the blood and urine of these patients had been carried out. The cases were associated with uræmia, diminution of urine, and lethargic symptoms. There was high blood urea, but the kidneys on microscopic examination showed no particular evidence of kidney insufficiency.

Doctor Eliot said he had no experience with the blood urea content. The paper was most instructive and everybody would emphasize the need of early and prompt exploration in any case of suspected obstruction. Doctor Eliot asked for an opinion as to the time at which aspiration of the contents of the intestine above the point of obstruction should be done. There was a sharp line of demarcation between the cases in which after relief of the obstruction the intestine could be returned intact and those in which either enterostomy or resection was indicated. He was inclined to believe that if either aspiration or enterostomy were indicated enterostomy was the preferable, for it added little to the operative risk and the opening either closed spontaneously (and this usually took place) or it could subsequently be readily closed by operation. In all cases in which the obstructed intestine was unquestionably viable neither aspiration nor enterostomy was necessary, for the amount of toxic absorption would not be sufficient to prevent recovery of the patient, though it might retard it. The experiments on dogs were very instructive, but how close was the relation between symptoms and lesions in dogs and those in human beings, and how advisable it was to draw inferences from experiences in dog surgery to similar conditions in human surgery was debatable. That the peritoneum of the dog was more tolerant than that of the human being could not be gainsaid. Perhaps this increased peritoneal tolerance accounted for the fact that continuity of the intestine after ligation was occasionally, as Dr. van Beuren mentioned, spontaneously restored. In the human being with the same degree of acute constriction at the same distance from the stomach the symptoms would be very much more aggravated and the course much shorter than in dogs, for these are among the worst cases of obstruction. From this standpoint, at least, the clinical subjective and objective symptoms in dogs and in human individuals were unlike.

Dr. Charles N. Dowd said there were many elements which aided in determining the proper method of dealing with intestinal obstruction. One of these elements was the point of obstruction. The symptoms from obstruction in the upper part of the intestine and those in the lower part of the intestine differed materially. Vomiting and prostration come early in high-lying obstructions, whereas an obstruction might exist for a long time in the sigmoid without giving severe symptoms. Frequently such obstruction might exist for many days. In determining the time of operation and in planning the method of operation this element should be duly considered.

Dr. John A. Hartwell said the lack of water was a most important factor. In some experimental work done by him and Doctor Hoguet one could keep dogs alive no matter where the obstruction occurred, provided they had sufficient water subcutaneously, except in cases where serious damage to the mucosa resulted. With such damage they would die in spite of receiving the water. The degree of this damage seemed

to depend upon whether a reverse peristalsis and vomiting was able to prevent overdistention of the bowel, the damage apparently resulting from mechanical stretching. In the case of the man with the strangulated hernia, his stormy convalescence was probably due to the fact that the intestinal mucosa had been damaged, thus producing the toxic elements which result from such damage.

Doctor Hartwell did not believe that the content of the intestine above the obstruction was seriously toxic if absorbed from the normal intestinal mucosa below the site of obstruction, after the latter had been relieved. The continued illness under these circumstances was probably caused more by the toxic absorption from the damaged mucosa than by the intestinal content, which, on the relief of the obstruction, was permitted to pass onward into the normal gut.

Doctor van Beuren, in closing the discussion, said that it had been found, in going over a series of ileus cases at the Roosevelt Hospital, that a large number of patients first seen in the later stages of the disease showed marked kidney damage with albumin and hyaline and granular casts in the urine. In response to Doctor Lambert's remark, he said that Dr. G. H. Whipple was the only man he knew of that had done work on the blood nitrogen of these cases.

In reply to Doctor Eliot's remarks on the different reaction of the peritoneum of dogs and of human beings, Doctor van Beuren said that similar results could be observed in both humans and animals but that, in cases of obstruction, perforations were apparently more common in dogs and the intestines on the whole were more easily damaged. He admitted that the difference was very striking between a high and low obstruction, the low obstruction being much less severe; but he said that it was a difference of severity rather than a difference in the quality of the symptoms, and that the replacement of water lost by vomiting sometimes made all the difference between death and recovery in the very sick cases. He repeated that early drainage of intestines was important inasmuch as it was not known how soon the poisonous character of the obstructed contents was absorbed, and he maintained that cases drained early showed a marked improvement.

He explained that there were only three ways of emptying the intestines, by mouth, by anus, or at some point between, and cited his three cases shown that evening as examples of the three types.

BOOK REVIEWS

UROLOGY IN MEN, WOMEN AND CHILDREN. By V. C. PEDERSEN, M.D., Urologist, St. Mark's Hospital, New York City. 8vo, pp. 991. Lea & Febiger, Philadelphia and New York, 1919.

In this work the author has attempted to put before practitioners the clinical and practical side of the subject of urology in its many phases, as is quite evident in the detail of the considerations of the etiology, pathology, symptoms, diagnosis, and treatment of the many subjects. The standard of cure is in each instance briefly stated, so that those not so familiar with the degrees of relief which may be expected from certain forms of treatment may realize that further effort in a given direction will only be a waste of time. This is a phase which we have not noticed in other treatises on this subject.

The general scope of urology is very well covered and in considerations of practice and exact procedure the author is particularly lucid, while the sections dealing with theory are rather more involved and while interesting do not read so easily. However, this is more than offset by the fuller text descriptions of his clinical experiences.

The correlation of the known facts relative to renal functional tests and hæmatological analyses are well expressed and of particular value to those having diagnostic and prognostic opinions to render when there is no specialist to make the interpretations. Not only are normal ranges given, but also pathological proportions and descriptive text of the probable causes of these variations.

The author is inclined to believe that the amplification of physical treatment is the next step in the advancement of urological science and practice, and therefore has devoted extended consideration to the subjects of hydrotherapy, heliotherapy, and electrotherapy, and gives much more definite directions regarding the instrument to be used, the type of application, its strength, duration, and frequency, than are usually found when these questions are taken up. A reliable foundation is given the reader upon which he may base such treatment in selected cases.

After-treatment is given careful, thorough, and well-merited prominence, as it is in just such subjects the young practitioner is deficient. If these directions would only be followed there is no doubt that many of the unpleasant sequelæ of urological diseases might be obviated.

Space such as is given to the controversy of the presence of the *micrococcus catarrhalis* in the urethal discharge or to its occasional presence in the normal urethra is useless to devote to this somewhat academic if not impractical question.

Much greater objection must be taken to the inclusion in a text-book of such matter as we find in the second paragraph on page 900, where in determining the degree of deformity of the renal pelvis the author counsels the employment of 10 per cent. collargol solution or 50 per cent. colloidal silver oxide, or 50 per cent. argyrol, quoting Braasch and Keyes, as authorities for its use. Both of these men have long since discontinued the use of these substances as actually dangerous and now use sodium bromide 25 per cent. solution with impunity and obtain equally if not more perfectly depicted pelves.

One cannot entirely subscribe to the statement on the same page that a renal pelvis holding 150 c.c. is usually of a non-operative type without qualifying remarks as to the etiologic factor in each instance—it gives one an entirely wrong impression in so baldly stating the above as a fact.

In general, the chapters considering disease of the urethra and bladder are more definite and show greater experience than those on the ureters, kidney, and prostate. The impression is that the work is deserving of presentation in two volumes, and the matter thus made less crowded and more readable and some chapters markedly amplified.

JAMES T. PILCHER.

THE PRINCIPLES OF ANATOMY AS SEEN IN THE HAND. By FREDERIC WOOD JONES, D.Sc., M.B., B.S. London. In one 8vo volume of 325 pages, 2 plates, and 123 text figures. P. Blakiston's Son and Co. Philadelphia, 1920.

In the words of the author, this book owes its inception to two circumstances. "First, it is the result of attempting to teach medical students such principles of anatomy as may be expected to interest them in their school work and assist them in their after-life as practitioners of medicine. But more immediately its origin is due to the necessity of choosing some circumscribed study in applied anatomy as a subject for a series of lectures."

The subject matter is well and interestingly presented, and deals with the broad principles of Applied and Morphological Anatomy. No attempt is made to cover nor even consider the surgical anatomy of the hand. There are no suggestions as to the treatment of pathological conditions, "because we are concerned solely with normal anatomy." This normal anatomy is in no sense descriptive anatomy such as is found in our anatomical text-books. For instance, in considering the muscles, their origin, insertion, nerve and blood supply, and relations are not given. It is not the object of the author to describe in detail the course of all the blood-vessels found in the hand. The bones are not considered singly from an anatomical standpoint. The carpal, metacarpal, phalangeal, and digital formulæ, on the other hand, are worked out and presented very thoroughly. The ulnar-carpal articulation is discussed, for instance, as it is

found in the Macaque monkey. Light is thrown on the puzzling additional toe of the Dorking fowl. Twenty-six pages are devoted to The Flexure Lines, describing the differences found in the various races of man, and comparing them with those found in the different species of the monkeys. Many references to both the older and to the contemporary comparative anatomists abound throughout the text.

The reviewer considers that this book would be a valuable addition to any medical library, not because it would be used daily as a work of reference, but because it presents the subject from a standpoint with which the average medical man is not entirely familiar.

MERRILL N. FOOTE.

REGIONAL ANÆSTHESIA (Victor Pauchet's Technic). By B. SHERWOOD-DUNN, M.D. In one volume, 8vo, 204 pages, with 224 figures in the text. Philadelphia, F. A. Davis Company, 1920.

This work presents a concise and detailed description of regional anæsthesia as practiced by Victor Pauchet, of France, together with a résumé of the writings of Sourdat, Laboure, and Sherwood-Dunn. The text is supplemented by numerous clear-cut, well-drawn plates and figures illustrating its pertinent points.

According to the author, who has worked with Professor Pauchet, any and every conceivable operation, from radical excision of the superior maxilla to partial gastrectomy, may be satisfactorily accomplished under regional anæsthesia. To perfect the nerve blocking in the more difficult operations, it is essential to practice, first, on the skeleton, then on the cadaver, using a hatpin to localize the various foramina in the skull through which the nerves emerge, and to determine the exact positions of the different nerve trunks throughout the body.

For the complicated and more uncommon, as well as for the more common surgical procedures, such as removal of lipomata, sebaceous cysts, hand infections, hernioplasty, appendectomy, etc., explicit directions, full descriptions of the technic, and excellent diagrams are given.

The book is an aid, both to the surgeon and to the practitioner, who may be called upon to use regional anæsthesia. It is a plea to the surgical profession to use, more and more, this method rather than that of general anæsthesia, in all surgical operations.

MERRILL N. FOOTE.

THE AFTER-TREATMENT OF SURGICAL PATIENTS. By WILLARD BARTLETT, A.M., M.D., and Collaborators. In two volumes. St. Louis, C. V. Mosby Company, 1920.

In consideration of the many surgical patients who are made more comfortable by properly directed after-care and the few who are actually lost because of the lack or misuse of it, this work is intended to appeal

to those who desire this important subject treated more in detail than is possible in the average system of surgery.

The author truly states in the preface that in the majority of instances the need of surgical after-treatment is in inverse proportion to the accuracy of pre-operative study and the quality of work done in the operating room; a viewpoint with which the reviewer heartily concurs.

Doctor Bartlett and his collaborators have compiled this work in two volumes, the first of which deals with general subjects in surgical after-care and the second with special measures of after-treatment as applied to the various regions and organs of the body. It should be noted in Volume One that thirty-four of the seventy-two chapters have been contributed by Dr. O. F. McKittrick, and these chapters comprise a complete, well-balanced and authoritative review of the more important anæsthetic and operative sequelæ and complications together with their proper management.

This volume begins with a description of the ideal room for the care of patients who have been operated upon and includes chapters on records and charts, the after-effects of anæsthesia, shock, hemorrhage, and the cardiovascular disturbances, acute dilatation of the stomach, post-operative ileus, pulmonary and fat embolism, acidosis, diabetes, nephritis, the various types of bacteriæmia and general infections, the management of operative wounds, the care of the bowels and bladder, dietary measures and artificial feeding, the scope of radium and the X-ray in malignancy, proctolysis, hypodermoclysis, blood transfusion, exercise, massage, hydrotherapy and the reconstruction of the surgical patient.

There is probably no single contribution more important than the chapters which deal with the physical, nutritional, and mental reconstruction of the surgical patient: factors which surgeons have been too prone to disregard, but the necessity and importance of which have been amply proved and exemplified by the experiences of the recent war.

Volume One is concluded with a discussion of post-operative mortality, together with a presentation of some statistical tables representing the combined mortality percentages of a number of operators and hospital clinics in the various types of operations.

In the second volume after-treatment is considered in its relation to the surgical procedures as applied to the various regions of the body. It is here that some phases of operative technic are, of necessity, described and illustrated in order that the reader may have a better understanding of the indications for, and application of, many of the more important post-operative measures.

The volume includes sections on the head and neck, the thorax and abdomen and their contained viscera, urologic and rectal conditions, vaginal and pelvic operations, and the surgery of the extremities, including orthopædics.

The work is complete and compiled with painstaking attention to

details; it is well and abundantly illustrated with original drawings and contains many suggestions of value which should prove helpful not only to students, hospital internes, and junior surgeons, but also to the surgeon of experience.

A definite field of usefulness is predicted for this work.

WALTER A. SHERWOOD.

To Contributors and Subscribers:

All contributions for Publication, Books for Review, and Exchanges should be sent to the Editorial Office, 145 Gates Ave., Brooklyn, N. Y.

Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS *of* SURGERY
227-231 S. 6th Street
Philadelphia, Penna